

https://dspace.org/

Pedagogical practices of mathematical literacy educators

Martin, Cameron Robert

2016-07-25
http://hdl.handle.net/10539/20699

Downloaded from a DSpace repository. https://dspace.org/

University of the Witwatersrand

School of Education

Pedagogical Practices of Mathematical Literacy Educators

By: Cameron Robert Martin

Student Number: 694722

Ethics Protocol Number: 2014ECE055M

Research Project in Education for:

Masters in Education

Supervisor: Tanya Bekker

University of the Witwatersrand, Johannesburg

School of Education

SENATE PLAGIARISM POLICY

Declaration by Students

I Cameron Robert Martin (Student number: 694722) am a student registered for Masters in Education in the year 2016. I hereby declare the following:

- **I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.**
- **I confirm that ALL the work submitted for assessment for the above course is my own unaided work except where I have explicitly indicated otherwise.**
- **I have followed the required conventions in referencing the thoughts and ideas of others.**
- **I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this in not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.**

Signature: _____ Date: _____

Acknowledgements

It is with the sincerest gratitude that I thank (soon to be) Dr. Tanya Bekker for her unbelievable support and guidance through the Masters process. Your humor, patience and wisdom have been greatly appreciated through this journey. I could not have done this without you.

I would also like to thank my parents, Anne and Nick Martin for both their financial and emotional support throughout the years of my education. They are the reason I push myself further than I ever thought possible.

To my brother, Alasdair Martin, for his invaluable help in generating the graphs that helped me illustrate my points so aptly.

And lastly, to all the education lecturers at WITS School of Education with whom I engaged with in the last four years of my studies: Thank you for your long lectures, seemingly boundless patience, and your unwavering commitment to the highest academic standards.

Abstract

This study analyzed the pedagogical practices of three Grade 10 Mathematical Literacy (ML) educators. The rationale behind the study was to add information and insight into the very new and under researched Further Education and Training secondary school subject of ML. Botha (2011) discussed how one of the main concerns with ML integration into the South African national curriculum was that the educators being asked to teach ML were moved into it from other subjects without any real education or training, and so when teaching, relied on previously learned pedagogical practices from other subjects. It is the contention of this study that this is a real issue in terms of the teaching of ML in classrooms and in terms of damaging its perceived academic status. In order to offer insight into how ML is its own distinct subject and not simply a lesser version of Mathematics, this study analyzed three lessons of each of the three educators through the lens of Pedagogical Link Making (PLM) (Scott, Mortimer, & Ametller, 2011). PLM was the conceptual framework that guided the observations and post observation interviews, and through analysis of the educators' pedagogical practices as well as a thematic analysis of discussion points during the interviews, this study came to five major findings. The findings suggested that the ML educators were not properly educated in ML pedagogy and that the educators made the majority of pedagogical decisions in the classroom based on generating learner interest and motivation for work. It also found that the educators used many of the links outlined by PLM, but also admitted to holding a lower academic expectation of ML and ML learners. A call is made to increase research into the relatively new subject of ML along the lines of pedagogical practices in order to assist new ML educators to translate and transmit the goals and content of ML provided for by the Curriculum and Assessment Policy Statement (CAPS) ML document.

Table of Contents

Declaration by Students 2
Acknowledgements 3
Abstract 4
Chapter One: Introduction to the Report 10
1.1 Introduction 10
1.2 Background to the Study 10
1.3 Problem Statement 13
1.4 Purpose Statement 15
1.5 Research Questions 16
1.6 Rationale 16
1.7 Conclusion 17
Chapter Two: Conceptual Framework and Review of Literature 18
2.1 Introduction 18
2.2 Mathematics vs. Mathematical Literacy 18
2.2.1 Mathematics vs ML – a dichotomy 19
2.2.2 Scientific vs Everyday – a breakdown of knowledge and understanding 22
2.2.3 Pedagogy 24
2.2.4 Pedagogical Link-making 26
2.2.5 Overview 30
2.3 Conclusion 30
Chapter Three: Methodology and Research Design 32
3.1 Introduction 32
3.2 Research Design 32
3.2.1 Qualitative research 32
3.2.2 Case Study 33
3.2.3 Research Site and Participants 33
3.2.4 Sampling 34
3.3 Data Collection Process 34
3.4 Data Collection Instruments 34
3.4.1 Semi-structured interview: 34
3.4.2 Observation: 35
3.4.3 Audio recording: 36
3.4.4 Document Analysis 36

3.5 Data Analysis 37
3.6 Compliance with Ethical Standards 38
3.6.1 Validity 39
3.6.2 Research Bias 39
3.6.3 Trustworthiness 39
3.7 Conclusion 40
Chapter Four: Data Analysis 41
4.1 Introduction 41
4.2 Observation Descriptions 43
4.2.1 Mrs. A 43
4.2.2 Mr. *B* 43
4.2.3 Ms. C 43
4.3 Pedagogical Link Making (PLM) 44
4.3.1 Approach one 44
4.3.2 Approach two 48
4.3.3 Approach three 51
4.3.4 Insights into the use of Pedagogical link making 54
4.4 Thematic Analysis 56
4.4.1 Familiarization with the data 56
4.4.2 Generating Initial Codes 56
4.4.3 Searching for themes 58
4.4.4 Review Themes 59
4.4.5 Defining and Naming Themes 59
4.5 Discussion of Themes 60
4.5.1 Theme one: Prevailing perspectives of ML 60
4.5.2 Theme two: Motivation and Discipline of learners 62
4.5.3 Theme three: Educator Training 66
4.6 Overall Findings 68
4.6.1 Finding One: ML Educators utilize a variety of links in their pedagogical practices 68
4.6.2 Finding Two: The type of link used is related to both the timing in the lesson and the complexity of concepts. 68
4.6.3 Finding Three: The perception of ML by ML educators affects their pedagogical decisions and practices. 69
4.6.4 Finding Four: ML Educators make pedagogical decisions based on generating learner interest 70

4.6.5 Finding Five: ML Educators believe they are not effectively trained or educated in terms of ML pedagogy 71
4.7 Reviewing the CAPS document 72
4.8 Conclusion 73
Chapter 5: Discussion of Findings and Conclusion 74
5.1 Introduction 74
5.2 Relating Overall Findings to the Research Questions. 74
5.3 Significance of Findings 76
5.4 Recommendations for Future Research. 78
5.5 Limitations of this Study. 79
5.6 Personal Reflection. 80
5.7 Conclusion. 81
Reference List 82
Appendix A 87
Appendix B 88

List of Tables

Table 3.1: Sample of the post-observation unstructured interview…….. 34

Table 3.2: Sample of Observation Schedule……..…….35

Table 4.1: Examples of the use of Approach one by Participants…..……..46

Table 4.2: Examples of the use of Approach two by Participants……. ……..48

Table 4.3: Example of interview transcript taken from Part 1: Teacher experience and qualifications……..55

Table 4.4: Initial codes for interview with Mrs. A…….56

Table 4.5: Initial codes for interview with Mr. B……..56

Table 4.6: Initial codes for interview with Ms. C……..56

Table 4.7: Initial codes for all Participants colored to indicate similar themes…….57

Table 4.8: The reviewing, defining and naming process……58

Figures

Figure 4.1: Visual Outline of Data Analysis ……..…….....41

Figure 4.2: Approach Usage ……..63

Figure 4.3: Illustration of Approach Observation…….64

Chapter One: Introduction to the Report

1.1 Introduction

In recent years, much attention has been paid to improving the Mathematics results of high school learners both internationally and in South Africa. In South Africa high school learners are offered the choice between taking conventional Mathematics or Mathematical Literacy (ML) as subjects in the Further Education and Training (FET) Phase of schooling. ML is still in its infancy in South Africa and forms the focus of this research report.

Chapter One will introduce the research report and highlight its place within the greater sphere of education research in South Africa. It will explain the background of the study and how it can add to the progress of educational research in South Africa with specific reference to subject of ML. It will also highlight some of the key concepts that help support and structure the study. It will frame the specific problem and purpose of the research and offer the key questions that will guide the research.

1.2 Background to the Study

The South African educational system is struggling to compete on the international stage, with Science, Mathematics and Literacy scores being well below the global average. In 2012, the World Economic Forum's annual report stated that South Africa has the lowest levels of Mathematics and Science education out of the 62 countries examined (Gernetzky, 2012). Angie Motshekga, the South African Minister of Education, reported that in 2012 the average Mathematics score at Grade 6 level was just 27%, with only 26.6% of Matric students achieving results that allow for university entrance (Motshekga, 2013). Prior to this announcement, Motshekga announced that the Annual National Assessment (ANA) for Grade 9 Mathematics and literacy levels revealed an average of just 13% for Mathematics across South Africa.

With this being the current state of education in South Africa, there is an intensive drive to try and solve these problems. Shepard (2000) explains Bernstein's notion that, within education, there are three major domains that interact and integrate to form a holistic educational system. These domains are Curriculum, Assessment and

Pedagogy and each of these domains are being explored for potential solutions to the problems facing South African education and those faced around the globe.

Curriculum has been the main focus of education reform in South Africa as – since the abolition of apartheid in 1994 – it has undergone a number of changes for a variety of reasons. Hoadley (2011) gives a concise summation of the key developments surrounding the evolution of curriculum in South Africa. Upon the dissolution of apartheid, there was a major push for the restructuring of the national curriculum towards the internationally recognized system of Outcomes Based Education (OBE). OBE was seen as a way to redress some of the key issues in education and South African society, but this did not prove to be the case. OBE came under fire on a number of key educational points (Jansen, 1998), which ultimately lead to its downfall in the South African curriculum. As Carrim (1998, p. 67) shows the change in curriculum was to move away from the biased, divisive ideologies of apartheid and move into a system of fairness, equity and social justice.

The new curriculum was termed Curriculum 2005 and was fueled by the major political change of the time. Chisholm (2005) takes an in-depth look at the socio-political pressures that influenced the formation of Curriculum 2005. She highlighted that with the new found freedoms and powers, the people and organizations of South Africa were able to voice what they thought should be present in the national curriculum. This ranged from vocational to economic to religious lobbies, and due to the major emphasis placed on fairness and social justice at the time, these were heard and taken into consideration. Curriculum 2005 was then simplified and presented as The Revised National Curriculum, and then modified into the Curriculum and Assessment Policy Statements (CAPS) which reframed and outlined the key content and assessment required for each of the subjects, and it is from the CAPS document that this research report will extract it's understanding of goals and methods of the National Curriculum. Throughout this process content, pacing and sequencing of all subjects underwent changes.

One such change to the national curriculum was the addition of ML. ML is a subject that is offered in the Further Education and Training (FET) Phase of the current National Curriculum Statement (Grades 10-12) as an alternative for Mathematics. ML is a subject that looks to generate what Kilpatrick (2001) and Julie (2006) calls

Mathematical proficiency in the learners – Mathematical proficiency being the ability to understand and apply mathematical concepts to solve problems. The major distinction between Mathematics and ML is the engagement with abstract concepts in the former and engagement in more contextualized concepts in the latter. Thus, those learners who are more capable and comfortable with working and engaging with more abstract concepts and structures continue with Mathematics, but those who struggle can choose to take ML.

The main aim of ML is to generate learners who can readily enter into society (Department of Basic Education, 2011a). The learners should be able to manage themselves effectively within the everyday activities that involve numbers and numeracy, for example, home finance, and budgeting both personally and for a small business or enterprise. Additional aims include preparing the learners to be able to apply some problem solving and organizational abilities to such tasks as map reading, spatial awareness and maneuverability, and understanding more complex instructions and societal functions.

Given these aims, the ML curriculum has presented a solution to help combat the low averages in Mathematics while allowing more mathematically, lower-achieving learners to get an education that allows for successful integration into the South African society. However, while the curriculum domain is progressing forward, the pedagogical domain is registering some issues.

There are fundamental differences in the implied pedagogical notions given by the latest Curriculum Assessment Policy Statements (CAPS) in that ML educators are required to place concepts within a real life context in order to generate practical decision-making and communication skills within the learner (Botha, 2011). Brown and Schaefer (2006) emphasized the contextualized nature of ML and as a direct consequence, the pedagogical emphasis is based on relating concepts to everyday activities and contextualizing knowledge. Unfortunately, as ML is still in its infancy in South Africa – and indeed globally as South Africa is the only country to currently position the subject within its national curriculum – there has been little research into either its efficacy in resolving the mathematical issues of the country, or more importantly, adding educational value to those learners who choose to take it. While it will still be years before any real data can be collected on such topics, a more

pressing issue is that there are very few educators that are qualified and trained in ML pedagogical practices.

Currently, the tendency of schools is to utilize Mathematics educators to teach ML (Botha, 2011), but as there is a fundamental difference in educational aims, goals and outcomes, is this a viable decision? The short answer is “we don’t know.” There is currently no data pertaining to this question for the reasons stated above, and very little research into generating much data. Added to this, the general problem of the widening gap between new, progressive curricula trends and “traditional” teaching practices and assessments means that there is confusion between styles of teaching, applicable content and new terminology. This has run rife amongst South African teachers (Jansen, 1998) and as a result of this, pedagogical practices are essentially an eclectic mix of past and present practices with no real regulation.

In this reality, research into the current pedagogical practices of ML educators becomes an integral part in starting to generate data about the efficacy of ML both now and into the future.

1.3 Problem Statement

With the introduction of the new Curriculum and Assessment Policy Statement (CAPS) being implemented in South African education (2011), there is a greater focus on the enacting of the curriculum within the educational institutions of South Africa. While there is a primary focus, both nationally and internationally on the core subjects of Mathematics and Science, the progression and development of South African specific subjects seems to be deprioritized. ML is one such subject that looks to provide an academic avenue to those learners who struggle with traditional mathematical concepts and abstractions.

As part of the National Curriculum Statement (NCS) of South Africa, when learners enter the Further Educational and Training (FET) Phase of their education, they are presented with a choice of either progressing with Mathematics or taking the subject of ML. The key distinction between the two is that while Mathematics requires learners to engage in theoretical concepts in a more abstract way, ML is based within a real life context. The NCS Curriculum and Assessment Policy (CAPS) (2011, p. 9) ML document gives five key elements of ML. Those are:

- To involve the use of elementary mathematical content
- To involve authentic, real-life contexts
- To solve both familiar and unfamiliar problems
- To involve decision making and communication
- To use integrated content and/or skills in solving problems.

From these five elements, we can see that the intention of ML is to provide learners with real life experience within the area of numeracy and numbers in order to function adequately in society. It aligns itself with the general aims of the South African curriculum by trying to create functional citizens that are able to work successfully in South African society.

From a Piagetian view of education this seems straight forward. Piaget (1964) stated that learning was only possible when “active assimilation” was present and so, by engaging the students in real life contexts, ML may seem to be educational solid. However, the constructivist learning theory given by Vygotsky (1978) argued that learners need to engage with abstract concepts in order to develop stronger concepts, to develop more complex systems of concepts, and to develop more efficient higher mental functions. In other words, the learners need to have some interaction with content that is removed from everyday situations and have a greater level of generality across situations. Herein lies the educational tension. Vygotsky (1978) illustrated this when he made the distinction between scientific and everyday concepts.

For Vygotsky (1978) everyday concepts are concepts that are derived from and based in everyday interactions and experiences of the learner. These concepts are functional in nature and allow for humans to engage in social activities in order to be a part of that society. Everyday concepts exist and are utilized within a specific context and based within the specific societal practice. Scientific concepts are concepts that are removed from a context and are more general in nature. They are more abstract and help organize and structure general patterns of thought across a variety of contexts. This has also been linked to the school based academic knowledge and concepts taught within the content of the curriculum, specifically within Mathematics and Science.

The importance of this distinction is that, in order for learners to progress and generate higher mental functions, the learner needs to engage and work with scientific concepts with the guidance and instruction of a more progressed individual (Vygotsky, 1978). This is the tension between the expectations of the CAPS document and a prominent learning theory.

This report makes the argument that pedagogy is the key to negotiating the tension between the imperative of the curriculum to focus on everyday functional aspects of Mathematics and the predominant learning theories that suggest that underlying abstract or scientific concepts are necessary for deeper understanding of these everyday concepts. As such, an analysis of the pedagogical practices of ML teachers would allow for a deeper insight into the current negotiation of the tension in order to generate meaning within the ML learners. A concept that has helped the analysis of such a task – albeit within science education – is that of *Pedagogical Link-Making (PLM)* (Scott, Mortimer, and Ametller, 2011)

"Pedagogical link-making is concerned with the ways in which teachers and students make connections between ideas in the ongoing meaning-making interactions of classroom teaching and learning."

(Scott et al., 2011. p. 3)

The problem is that Mathematical Literacy educators are expected to negotiate the tension between the prescribed curriculum and more prominent learning theories within their pedagogical practices in the classroom without the years of data and experience that other subjects have. Using PLM as a model for analysis, we can start to analyze the preferences or choices of educators towards either the use of more everyday concepts and methods of description or the use of more scientific concepts and descriptions. This would give researchers, curriculum developers and the ML educators themselves a base line from which to develop appropriate and efficient pedagogical guidelines for ML.

1.4 Purpose Statement

The purpose of this research report is to establish a base of comparison between the demands of the CAPS document for ML and the current pedagogical practices in the classroom. Through observing and analyzing Grade 10 ML educators and comparing

the pedagogical practices to those implied or prescribed by the CAPS documents, we can establish a base for both comparison and development of ML pedagogical practices.

To do this, we need to analyze the current pedagogical practices of the ML educators within the classroom. With a deeper understanding of the general ML pedagogy employed by the educators, closer attention can then be placed on the specific use of links to help learners develop concepts. This would then give us insight into how educators negotiate the tension between scientific and everyday concepts in the classroom.

It is important to note that this paper does not look to propose an ideal ML pedagogy. That would need a much broader exploration and far greater time frame. This report will focus on analyzing empirical data gathered in the ML lessons and relating it to an analysis of the CAPS document in order to determine how educators are currently teach ML and how this relates to the information provided in the CAPS document. Potentially, this could set the platform for further research into improving ML pedagogy, realigning CAPS goals and aims for the subject, analyzing potential problems in curriculum uptake in teachers, or even analyzing the efficacy of ML within the greater South African curriculum.

1.5 Research Questions

The following research questions are proposed for this study:

1. What pedagogical practices are utilized by ML educators in the classroom?

2. In what ways do ML educators utilise links to negotiate the balance of everyday and scientific concepts within their pedagogical practices?

1.6 Rationale

As a both a Grade 8 Mathematics educator and a Grade 10 ML educator, I have experienced first-hand how pedagogical practices in both subjects may start under the same mathematical banner, but ultimately develop along very different paths. I am a firm supporter of the presence of ML as I have seen the positive experiences of ML learners who have struggled with the theoretical engagement with abstract

concepts during their first 9 years of basic education being able to engage at a higher level with more contextualized knowledge and situations. Yet ML is still viewed as a “dumbed down” Mathematics rather than its own, separate subject with different aims, goals, and specifically its different pedagogy.

By investigating the current pedagogical practices of ML educators, and comparing these to those proposed by the CAPS document, a deeper insight into the ML as its own subject can be obtained. Moreover, by analyzing the presence of scientific and everyday concepts, we can potentially start to see the current shape and form of ML pedagogy and how it is starting to identify itself from those of Mathematics.

1.7 Conclusion

This chapter has proposed the reasons for the research and outlined exactly why research in the field of ML is so greatly required. It has provided the relationship between the specific focus of the study to the greater domain of education in South Africa and offered possible paths for future research to build upon. The next chapter – the literature review – will provide a more in depth exploration into the subject of ML and the specific aspects of pedagogy that this report intends to focus on.

Chapter Two: Conceptual Framework and Review of Literature

2.1 Introduction

While Chapter One has outlined the research report, Chapter Two will explore the concept of ML in greater depth. This chapter will provide a preliminary distinction between Mathematics and ML as given by the National Curriculum Statement of South Africa. The distinction will be made more pronounced through discussion of the educational learning theory given by Lev Vygotsky (1978). It will then highlight the importance of pedagogy in the development of learners, and finally, it will provide a conceptual framework with which to analyze the pedagogical practices of ML educators in order to help ML to form its own identity in pedagogical terms.

2.2 Mathematical Literacy

With the introduction of ML (ML) into the educational curriculum of South Africa in 2006 (Botha, 2011), learners entering into the Further Education and Training (FET) Phase of education have been given a choice whether to continue with Mathematics as a subject or elect to take ML as credits towards their National Senior Certificate (NSC) at the end of Grade 12. South Africa is the first country in the world to offer ML as a school subject (Christiansen, 2007), and as such there is little research on either the efficacy of the subject in the national curriculum as a whole, or the pedagogical practices of ML educators at the three levels of education in the FET Phase (Grades 10, 11 and 12). Thus the purpose of this research report is to gain insight into the pedagogical practices of educators within ML and how they negotiate the tension between the scientific concepts and everyday concepts in the curriculum through the use of link-making.

This review of literature will look to contrast ML with Mathematics with the aim of locating a key tension in ML as a subject that ML educators are required to negotiate. The tension will then be further defined through the exploration of scientific and everyday concepts in relation to the requirements of the Curriculum Assessment Policy Statement (CAPS) of 2011. We will then introduce and examine the process of PLM given by Scott et al. (2011), and how it can be refocused onto ML and utilized as a lens with which to examine ML pedagogical practices.

2.2.1 Mathematics vs ML – a dichotomy

Keeping in mind that South Africa is the first in the world to use ML as a formalized subject with academic purposes rather than a state of being or level of skill related to understanding mathematical concepts which is used internationally (Botha, 2011), there needs to be a clear definition of ML on which to base our research.

According to the National CAPS document for ML (Department of Basic Education, 2011a) ML is a subject offered to learners entering into the FET Phase of the national curriculum. ML is a subject that has the key pivotal goal of addressing the poor levels of mathematical ability within South Africa as shown in the Trends in International Mathematics and Science Study (TIMSS) in 2003 (Botha, 2011).

ML is the subject used by the Department of Basic Education to address the number of goals and aims of the curriculum that align to generate mathematical ability within the large percentage of the South African population who struggle to grasp and engage effectively with the more abstract concepts of the traditional Mathematics content. According to the ML CAPS document (2011a) there are five key elements to ML:

1. ML involves the use of elementary mathematical content:

> *The mathematical content of ML is limited to those elementary mathematical concepts and skills that are relevant to making sense of numerically and statistically based scenarios faced in the everyday lives of individuals (self-managing individuals) and the workplace (contributing workers), and to participating as critical citizens in social and political discussions. In general, the focus is not on abstract mathematical concepts. As a rule of thumb, if the required calculations cannot be performed using a basic four-function calculator, then the calculation is in all likelihood not appropriate for ML. Furthermore, since the focus in ML is on making sense of real-life contexts and scenarios, in the ML classroom mathematical content should not be taught in the absence of context.*
>
> (Department of Basic Education, 2011a, p. 8)

2. ML involves authentic real-life content:

In exploring and solving real-world problems, it is essential that the contexts learners are exposed to in this subject are authentic (i.e. are drawn from genuine and realistic situations) and relevant, and relate to daily life, the workplace and the wider social, political and global environments. Wherever possible, learners must be able to work with actual real-life problems and resources, rather than with problems developed around constructed, semi-real, contrived and/or fictitious scenarios. E.g. learners must be exposed to real accounts containing complex and "messy" figures rather than contrived and constructed replicas containing only clean and rounded figures.

(Department of Basic Education, 2011a, p. 8)

3. ML involves solving familiar and unfamiliar problems:

It is unrealistic to expect that in the teaching of ML learners will always be exposed to contexts that are specifically relevant to their lives, and that they will be exposed to all of the contexts that they will one day encounter in the world. Rather, the purpose of this subject is to equip learners with the necessary knowledge and skills to be able to solve problems in any context that they may encounter in daily life and in the workplace, irrespective of whether the context is specifically relevant to their lives or whether the context is familiar. Learners who are mathematically literate should have the capacity and confidence to interpret any real-life context that they encounter, and be able to identify and perform the techniques, calculations and/or other considerations needed to make sense of the context. In this sense ML develops a general set of skills needed to deal with a particular range of problem. (Department of Basic Education, 2011a, p. 9)

4. ML involves decision making and communication:

A mathematically literate individual is able to weigh up options by comparing solutions, make decisions regarding the most appropriate choice for a given set of conditions, and communicate decisions using terminology (both

mathematical and non-mathematical) appropriate to the context. In the teaching of ML, teachers should provide learners with opportunities to develop and practise decision-making and communication skills.

(Department of Basic Education, 2011a, p. 9-10)

5. ML involves the use of integrated content and/or skills in solving problems:

The content, skills and contexts in this document are organised and categorised according to topics. However, problems encountered in everyday contexts are never structured according to individual content topics. Rather, the solving of real-life problems commonly involves the use of content and/or skills drawn from a range of topics, and so, being able to solve problems based in real-life contexts requires the ability to identify and use a wide variety of techniques and skills integrated from across a range of content topics.

(Department of Basic Education, 2011a, p. 10)

As can be seen, ML is a subject in the South African curriculum that is defined by its aims and processes rather than a statement of being or level of mathematical ability which is the prominent international conception. It is here that we can draw some comparisons between ML and traditional Mathematics. According to the national CAPS document on Mathematics (Department of Basic Education, 2011b), Mathematics is:

"… a language that makes use of symbols and notations for describing numerical, geometric and graphical relationships."

(Department of Basic Education, 2011b, p. 8)

The subject, therefore, has a main aim of inducting learners into this language in order for them to develop fluency in engaging mathematical and higher thinking skills. While both Mathematics and ML are to include contextualized examples and content, the aim of Mathematics is to promote and push the higher mental functions of generalizing these examples to a variety of situations and more complex examples. The first element of ML places limits on this progression into higher order thinking as it focuses on *elementary* mathematical content. As Hope (2007)

discussed, both Mathematics and ML as subjects aim to allow learners to apply mathematical content to real-world situations, while Mathematics would incorporate higher degrees of complexity than ML. Venkat (2010) discusses a “prevalent feature” of ML having a “life-preparation orientation” which emphasizes the split in complexity with Mathematics. The key mathematical issue found by Venkat (2010) was that while ML limited the abstraction and generalization of mathematical concepts, it strongly featured traits such as strategic competence, adaptive reasoning, and developments of a productive disposition.

It is not enough to just make the claim that there is a difference in the levels of complexity between the two subjects, as it is by examining the difference that a more distinct and helpful dichotomy can be achieved. To do this we will work with the concepts of scientific and everyday knowledge.

2.2.2 Scientific vs Everyday – a breakdown of knowledge and understanding

When analyzing the gap between elementary and higher forms of thinking and cognition, there needs to be a framework from which to work. For the purposes of this research report, the conceptual framework that we will follow is provided by Vygotsky (1978).

Vygotsky (1978) was a major contributor to the understanding of how people learned, or rather developed concepts within their thinking. Vygotsky (1978) believed that learning was socio-genetic in nature and thus originated through interactions within a social context, before being internalized by the learner and assimilated into their pre-existing structures of cognition and thought. Thus learning concepts preceded the cognitive development of the learner, and thus the engagement with more and more complex concepts allowed for learners to develop further than those who did not.

Vygotsky (1978) separated concepts into two categories. The first was everyday concepts. These are concepts that are engaged with through normal, day-to-day interactions with society. Bernstein (1999) classified these as spontaneous concepts, as these concepts were learned without real intention to learn, but rather were acquired from the necessary interactions to survive and live within a society. The

second category of concepts given by Vygotsky (1978) were called scientific concepts. These were defined by their removal from context specific engagement to a more abstract, generalizable nature. Bernstein (1999) called these non-spontaneous concepts as these concepts were only engaged with through intention of engagement.

The dichotomy of concepts allowed Vygotsky (1978) to describe the process of learning as a movement between everyday concepts to scientific ones. He illustrated this when he discussed the Zone of Proximal Development (ZPD). The ZPD describes the distance between the conceptual level a learner can reach without assistance and the conceptual level a learner can reach with assistance. The key point here is that by assisting a learner to engage with more complex scientific concepts the learner can assimilate it into the pre-existing cognitive systems and structure and thus reach a higher level of cognitive ability. By assisting the linking of the scientific concept to the everyday concepts, learners are able to establish a new, more complex base level of cognition and conceptual engagement which can be used as the new base to reach the next level of complex scientific concepts.

There are two key points to take from the ZPD. The first is that this process will take place in both Mathematics and ML. The difference, as we have already discussed, is that in ML the scientific concepts are limited to elementary mathematical concepts, while in Mathematics the scientific concepts are progressed further into more complex Mathematical concepts. This brings to the fore an important question: what or who decides on which mathematical concepts are deemed to be elementary? The macro answer to that question is quite complex as it would involve a global consultation as to what levels are deemed to be elementary and more complex. The micro answer is far easier and more relevant to this study in that it is those concepts that are deemed to be elementary by the national curriculum i.e. the Mathematics and ML CAPS documents. However, taking our understanding of elementary mathematical concepts from the ML CAPS document doesn't fully negate much of the ambiguity as the ML CAPS document does not specifically say which concepts are elementary and which are not. Thus, the study has to make some assumptions based on the content and assessment guidelines provided in the document.

2.2.3 Pedagogy

The second key point from the ZPD is the importance of the "assistance", or in our instance, the role and actions of the educator. The educator and their ability to help the learner link the pre-established everyday knowledge to new scientific knowledge will have a significant role in the development of that learner in mathematical concepts. While this is true across all subjects, curricula and educational systems, it adds a further dimension to the distinction between ML and Mathematics.

Botha (2011) discusses how the pedagogical approach to ML is different to Mathematics due to the nature of ML being more contextualized. Pedagogical practices need to be in line with the aims and goals of the CAPS document in order to achieve those goals. Bansilal (2014) emphasized the need for pedagogical learning in ML educators as they produce content and assessment methods, which needed to include and embrace the history and philosophy of ML. The problem facing the teaching of ML currently is a lack of precedents on which to base pedagogical practices (Graven & Venkat, 2007) due to the fact that ML is still in its infancy in terms of educational subjects. This has caused the educators to fashion a pedagogical approach to ML that is largely based on either the previous or alternate subjects the educators teach, or the general guideline of Mathematics which has far more research and background to work with. The major problem with this was suggested by Bowie and Frith (2006) when they discussed how the perception of ML could be interpreted as:

"… *a slightly toned-downed standard grade Mathematics with words sums."*

(Bowie & Frith, 2006, p. 32)

Standard Grade Mathematics was an alternate option to Mathematics given to those learners who struggled in traditional Mathematics prior to the introduction of ML. Standard Grade Mathematics had a similar curriculum to that of Mathematics, but was paced slower with the more abstract mathematical concepts removed, and so this is a real concern as ML and Mathematics are very different subjects with different content, aims, and outcomes. As Sidiropolous (2008, p. 208) stated:

"The distinction between ML and Mathematics is principally not a distinction in level, but a distinction in kind."

Thus the pedagogical approaches should be generated independently.

If we take this to be the case, how then do ML educators generate, or perhaps a better question is, how *should* they develop a pedagogical approach that allows for the fruition of ML learners to reach the desired levels of Mathematical competency to engage effectively in the South African society?

Alexander (2009) made the distinction between pedagogy and teaching. Teaching is seen as an act while pedagogy is the discourse surrounding the act, so while there is a distinction, Alexander (2009) states they are inseparable. In other words:

"Pedagogy is the observable act of teaching together with its attendant discourse of educational theories, values, evidence and justification. It is what one needs to know, and the skills one needs to command, in order to make and justify the many different kinds of decisions of which teaching is constituted." (Alexander, 2009, p. 927)

From this definition of pedagogy we can take two very important sources for the decisions to be made when generating an appropriate pedagogy. The first is the educational theories. While there are many to discuss and inform pedagogical decisions, one of the most dominant is from the work of Vygotsky, as we have discussed already. The key from this learning theory is the linking of spontaneously developed concepts and knowledge to the non-spontaneous, scientific concepts and knowledge of the specific subject. Thus ML educators would need to deeply consider this when generating a pedagogical practice.

The second source would be able to provide the *"…values, evidence and justification,"* as well as the knowledge and skills the ML educator would have to command, and that is comes from the National Curriculum Statements, and specifically the CAPS document for ML. This would significantly shape and influence the pedagogical practices generated by ML educators.

Herein lies the tension discussed in the problem statement. Educators are expected to be able to engage with both learning theory and policy to generate an appropriate and effective pedagogy for ML. They are expected to do this without decades of research, thought and experience in the implementation of ML as a subject, while trying to negotiate the numerous problems in the implementation of the South African educational system as a whole. Key issues such as weak subject knowledge of

teachers, ineffective teaching methods (Fleisch, 2007) as well as major problems in the training and education of educators into the CAPS curriculum processes (Olivier, 2013). While there can be (and are) a multitude of problems with the generation of effective pedagogy for ML, the current ML educators are doing just that – generating pedagogical practices in their classrooms. The real issue is that without analyzing the pedagogical practices current ML educators are using, there cannot be any real conclusion as to whether or not the pedagogies being generated are effective, standardized or even related to the CAPS policy.

This research report will look into just one aspect of the pedagogical practices of current ML educators, namely, the linking of everyday concepts and knowledge with the scientific concepts and knowledge provided for in the CAPS policy document for ML. In order to do this, we will attempt to utilize PLM which is a framework originally used in Science classrooms, to analyze the pedagogical practices of ML educators.

2.2.4 Pedagogical Link-making

Scott et al. (2011) put forward the concept of PLM as a way to analyze the process of education of disciplinary subject matter. PLM is:

"… concerned with the ways in which teachers and students make connections between ideas in the ongoing meaning-making interactions of classroom teaching and learning." (Scott et al., 2011, p. 3)

The focus here is that PLM looks to describe the process of making cognitive links from formalized required concepts to the pre-established cognitive structures of the learners in order to facilitate the understanding of a concept. In other words, the process of linking discipline specific scientific concepts to the learner's current understanding of the discipline, in order to for the learner to generate meaning. Scott et al. (2011) utilize Vygotsky (1978) to emphasize that meaning is developed when a leaner internalizes the concept and is able to reconstruct the concept using already understood notions. Vygotsky (1978) explained that the process of internalization illustrates how concepts are socio-genetic in nature; the concepts are engaged with or experienced within a social context and given meaning through the internalization process. For Scott et al. (2011), this meant that the educator needs to produce

similar links in the social plane of the classroom in order for learners to internalize not only the specific concept, but also the link-making process itself in order to generate more complex links and therefore deeper meaning of concepts.

Scott et al. (2011) further discuss how there are three forms of PLM. The first is to support knowledge building; the second is to promote continuity (primarily in recognition that education takes place over an extended period of time); and the last is to encourage emotional engagement. That is, to promote a positive emotional response of learners towards the learning in order to make the internalization and PLM processes easier and more effective. In order to maintain the scope of this research report we will focus on the first form: to support knowledge building. This will allow for a more concentrated observation on how ML educators look to engage learner in developing and internalizing ML concepts.

Within the first form, there are 6 approaches of PLM to support knowledge building. While we will explain all six of the approaches, we will focus on the first three as they are directly linked to our research and focus primarily on the work of Vygotsky, while the others, while still strongly related, have a slightly different focus.

The first of the approaches (Approach 1) explained by Scott et al. (2011) is *making links between everyday and scientific ways of explaining*. This approach focusses on the ability of both the educator and the learner to generate links between everyday concepts and scientific concepts using both everyday and scientific methods of explanation. An example of the difference given by Scott et al. (2011) is the description of energy. An everyday explanation of energy is that it is a "real substance" that is used up through exercise, while a scientific explanation is that energy is an abstract quantity that is not used up but rather conserved in a different form. The learner needs to be able to integrate the scientific explanation into his pre-existing cognitive structures by using his everyday explanation to help generate links, but the learner also needs to differentiate between the scientific and everyday explanations. It is just as important for the learner to know what energy *is not* as it is for the learner to know what energy *is* (Scott et al., 2011). A mathematical example would be in the explanation that diameter of a circle is a straight line going through the centre of the circle that intersects the circumference at two points. An everyday explanation for this would be a line that cuts a circle in half. Again the learner needs

to be able to assimilate the scientific explanation with the everyday explanation of dividing an object into equal parts.

The second approach discusses *making links between scientific concepts*. Here Scott et al. (2011) describe how learners do not only have to make links between scientific and everyday concepts, but also between scientific concepts that are relevant to each other within a certain context. An example here would be in order to gain a deep understanding of the scientific concept of algebra a learner would need to be familiar with the order of operations, the operations themselves, and exponents. In this way, the learner is connecting the different scientific concepts that help to process and explain a new or more complex scientific concepts.

Approach 3 is *making links between scientific explanations and real world phenomena.* According to Scott et al. (2011) learners engaging with scientific concepts within a scientific or abstract space need to make links to real world phenomena to provide a practical foundation for the scientific knowledge. Vygotsky (1978) discussed how the Zone of Proximal Development (ZPD) separated current level and potential level. In order to close the gap between the two levels, concepts are developed from two directions. The first is from the abstract to the concrete where scientific concepts are presented in verbal (abstract) form and linked to concrete concepts within the cognitive structures of the learner. An example of this is the introduction of a general formula that has numerous applications to solve a specific problem. The second direction is where, upon faced with a scientific concepts, concrete concepts are generalized into abstract form and linked to the scientific concepts. Concrete concepts are those concepts that are rooted in practical reality, and so by establishing links between real world phenomena and abstract scientific concepts, the learner is more readily able to close the ZPD and reach his or her potential. An example of this would be a learner experiencing an increase in their bank account at the end of the year and then linking it with the concept of interest.

The fourth is *making links between modes of representation*. The focus here is that the content to be taught or the knowledge that is desired to be taught can be presented in different modalities. Scott et al. (2011) use Lemke (1998) to highlight that science makes "*extravagant use"* of mathematical, graphical, and diagrammatic modalities. Thus the educator, in order to explain a particular concepts, can make

links to multiple modalities of representing the concept. In Mathematics, educators use a similar variety of modalities when discussing the concept of volume. Through graphical shapes, text based formulae, and real world experiments and experiences.

The fifth approach is entitled: *moving between different scales and levels of explanation.* Scott et al*.* (2011) refer to the three levels of representation given by Treagust (2007) to present their own three levels. The macroscopic of phenomenological level which sits at the level of experience of the learners, the microscopic or theoretical level which sits at the conceptual understanding of phenomena, and the symbolic level which deals with the symbolic language of science and society in order to describe and engage with the other two levels. For Scott et al*.* (2011), the linking between these levels of education is fundamental to a scientific approach to education, thus the moving and linking between these levels is vital to a scientific pedagogy.

The last approach is *analogical link-making.* This involves the use of more accessible or familiar case that relates to the concept being discussed. The key difference between the previous five approaches and this one is that, according to Scott et al*.* (2011) the use of analogies is *not* necessary for a deep conceptual understanding of scientific concepts. It is included as an approach in recognition of the prevalence in which analogies are used in current pedagogies.

The first three approaches have closest relation of concept development to the description and implied educational goals of ML given in the CAPS documents, and so this report will focus on the role the first three approaches have in the pedagogical practices of the observed ML educators. Educators can demonstrate all three of these approaches in their pedagogical practices in the classroom, and so we can then analyze the frequency, utilization and preferences of the educators in PLM within ML and therefore develop a base with which to inform commonalities and differences in current ML pedagogy.

The application of PLM as an analytical lens has been used before, and not only in traditional science education. Braund, Ekron, and Moodley (2013) used PLM as a basis to analyse the efficacy of using drama to teach science concepts. Mashinyira (2013) used PLM to see how students related what was observed in practical science lessen to the theory learnt in regular lessons. PLM has even been modified

into other subjects such as tertiary educational course on Research Methodology to analyze the efficacy of online, e-mediated learning (Khoo & Cowie, 2014). Thus PLM will provide a sufficient lens for analysis for this study.

2.2.5 Overview

This literature review has set out the major conceptual ideas that form the framework of this research report. It began with establishing the fundamental difference between Mathematics and ML by highlighting the limits and prescribed aims and goals of the ML CAPS document in relations to those of Mathematics. It then gave a brief explanation of the scientific and everyday concepts and how they are key to generating learning and development within learners, and how this related to both Mathematics and ML. We then placed the educator as a key influencing factor in the educational process and how an educators pedagogical practices are significantly influenced by learning theories (in our case that of Vygotsky) and the policies and prescriptions given by the national ML CAPS document.

This was where we placed the tension that educators need to negotiate: between the prominent learning theories that inform learner development and the *values, evidence and justifications* prescribed by national policy. The results of this negotiation is presented in the pedagogical preferences shown by the educator within the classroom, and so by using PLM as a framework for comparison, common trends and important differences can be analyzed and recorded for further investigation and research into the efficacy of ML education, for a base on which future ML educators can generate their own pedagogical practices, and for revision and modification of future curriculum changes.

While these are potential milestones in future studies, this study will focus analyzing and exploring the use of the first three approaches of Form One of PLM by Grade 10 ML educators.

2.3 Conclusion

This chapter has explored ML and highlighted the need for further research into this uniquely South African subject. Having shown the presence of key distinctions between ML and Mathematics – as well as the need to expand and develop those

distinctions – the emphasis is then placed on the role of the educator in utilizing and negotiating these distinctions in their pedagogical practices in the classroom.

The next chapter will explore just how the research will attempt to collect data and analyze pedagogical practices in order to deepen our understanding of the current pedagogical practices of Grade 10 ML educators.

Chapter Three: Methodology and Research Design

3.1 Introduction

The intention of this study was to analyze the pedagogical practices of Grade 10 ML educators with specific focus on the use of pedagogical links during lessons. Chapter Three will explain the methodology and research design of this report, which was positioned to help achieve the research aims. It will indicate the key concepts and research methods that form the basis of the enquiry and how the research tools are to be utilized. As ML is a subject taught in high schools in South Africa, the observation and data was collected there, and so ethical issues that were addressed to protect participants will also be covered. With these notions indicated and discussed, the research was streamlined towards extracting the necessary data while maintaining an ethical presence.

3.2 Research Design

The following section highlights the key attributes of this study in terms of its methodology and paradigm in order to investigate, collect and analyze the required data.

3.2.1 Qualitative research

According to Terre Blanche & Durrheim (1999) a research paradigm is an all-encompassing system of interrelated practice and thinking that define the nature of enquiry along the three dimensions of ontology, epistemology and methodology. Qualitative research is inquiry in which researchers collect data in face-to-face situations by interacting with specific people in their setting. This design technique analyses and describes individuals or people's social actions (McMillan & Schumacher, 2010). Researchers involved in qualitative research believe that individuals consciously construct their own understanding of the world through experience.

Creswell (1994, p. 1-2) sees qualitative research as an:

"… inquiry process of understanding a social or human problem, based on building a complex, holistic picture, formed with words…"

Qualitative researchers tend to start their work by asking general questions, then collecting large amounts of data and usually presenting their findings in words. As Creswell (2003) puts it, the questions tend to be "*open ended so that participants can express their views."* This is exactly the paradigm of this research report in that the pedagogical practices both observed and discussed within an interview are about understanding the social behavior of educators within a particular social situation. In other words, the educators' behavior within the classroom and trying to understand the reasons behind them.

3.2.2 Case Study

Merriam (1998, p. 27) defined a case study in educational research as:

"... an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly relevant."

The main focus of this research report is to offer insight into the pedagogical practices of ML educators at a Grade 10 level with specific reference to the linking of scientific and everyday concepts. The boundaries of link-making and meaning making between educator and learner as well as those between current practices and those prescribed by the curriculum are not clear at all and thus a case study is a natural choice to investigate the phenomenon.

According to Yin (2013) case studies are best used when the investigator has little or no possibility of controlling the events. This is very much the case in this study as the observations took place in a live classroom controlled by the teachers. Yin (2013) goes on to say that the general questions answered by case studies tended to be the "How?" and "Why?" research questions, which are the key questions for this study.

3.2.3 Research Site and Participants

The observations took place in public high schools in Northern Johannesburg. After all nine lessons were observed, the interviews were done at the same schools at the convenience of the educators. Three different Grade 10 ML educators participated in the study.

3.2.4 Sampling

Purposeful sampling was utilized as there needed to be specificity about the level of learners and the subject being observed. This research report looked to analyze the pedagogical practices of Grade 10 ML educators and thus purposefully chosen participants were needed for the investigation of the phenomenon in order to uphold the validity and credibility of the findings.

3.3 Data Collection Process

In order to collect the data, ethical clearance from the Gauteng Department of Education to observe educators within the classroom was needed. The observation lessons were selected from a specific topic within the ML Grade 10 CAPS curriculum. I then had a meeting with the principals of the schools to again ask permission to conduct the classroom observation and teacher interviews. I then addressed the relevant educators to ask for their participation after a detailed summary of the goals of the study as well as the ethical safe-guards were discussed. Lastly, I received the permission of both the learners of the ML classes and their parents and/or legal guardians.

Once all permissions were granted and informed consent obtained, I conducted an observation of each of the three participant educators over the course of three observed lessons per participant on a particular ML topic or set of topics. Once the observations had been done, a reflexive interview was undertaken with each of the educators. Once all educators have been observed and interviewed the data analysis continued.

3.4 Data Collection Instruments

The following instruments to collect the required data were used:

3.4.1 Semi-structured interview:

Semi-structured interviews involve a pre-existing set of questions, but allow the interviewer the flexibility to deviate and probe further if the need arises (McMillan & Schumacher, 2010). In unstructured interviews there are few prepared questions and the interviewer will phrase questions during the interview according to the responses

of the interviewee. Table 3.1 is an example of a structured question followed by an unstructured question that happened during one of the interviews.

Table 3.1: Sample of the post-observation unstructured interview

INTERVIEWER	ERN	PARTICIPANT
Interesting. ***During the Pythagoras lesson you used some questions that were not part of the textbook – you had the work page. Why did you do this and where was it from?***	**26**	Because I have been teaching pure maths for so long I have started to make my own notes. I also wrote two text books. One for Grade 8 and one for Grade 9. So I think, if you need more exercises then you have to create something for the kids.
Do you feel you need more exercises?	**27**	Yes, because there is not enough in the text book.
OK, so you were supplementing the lesson with your own work because you felt you needed more time on a specific concept?	**28**	Yes. Although they have done it in Grade 8 and 9. It is very interesting to see that they can't remember.

In Table 3.1, the bold and italicized writing is a structured, pre-planned question that arose from the observed lesson, but due to the answer of the participant, the next two questions are asked that were not planned. The idea here is to get deeper insight into the participant's reasoning for her answers. For the full interview transcription, see Appendix B.

Semi-structured interviews were used in this study because they allow for carefully prepared questions which ensure that all the areas of interest are covered, but also allows the interviewer to deviate and probe further, and in this way more detailed information can be obtained as interviewee's responses can be expanded upon. The pre-existing questions were formulated and placed within an interview schedule to create the structure, but the questions did allow for elaboration and thus follow up questions were employed.

3.4.2 Observation:

An observation is a non-participative viewing of a phenomenon that is required to be as unobtrusive as possible. The purpose was to observe the pedagogical practices of the ML educator and note down key links made during the lesson. The use of an observation schedule helped the observer keep track of key actions within the lesson

in relation to pedagogical link-making. The observation schedule was created primarily from the guidelines of the PLM framework provided by Scott et al. (2011), specifically Form One, Approaches one, two, and three. Table 3.2 provides an example of the observation schedule. For the full schedule, see Appendix B.

Table 3.2: Sample of Observation Schedule

Pedagogical Link Making	**Approach 1: between everyday and scientific ways of explaining**	**Approach 2: between scientific concepts**	**Approach 3: between scientific explanations and real world phenomena**
Event 1 **Time:**			
Event 2 **Time:**			

3.4.3 Audio recording:

All nine lessons (three per participant) were recorded through audio recording. The audio recording with the observation allowed the observer to reanalyze the lessons in order to reinvestigate patterns or findings, or to investigate unforeseen findings and patterns that arose during data analysis. The post-observation interviews were also voice recorded. The audio recording of the interview allowed for similar analysis and aided the interview transcriptions to be recreated more accurately.

3.4.4 Document Analysis

According to Schumacher and McMillan (2010) document analysis involves the analysis of the written or visual content of a document. This was used to analyze the ML CAPS document in order to form the base for comparison for pedagogical practices of the ML educators. It was also used as the key point of reference to scientific content of ML as a subject and so for the purposes of this research, scientific concepts for ML will be labelled as such due to their presence or reference within the national CAPS documents.

3.5 Data Analysis

The data was analyzed along two main pathways. The first was through the PLM lens which the observation and interviews were focused upon. The second was the use of thematic analysis. Braun and Clarke (2006, p. 6) described thematic analysis as:

"… a method for identifying, analyzing, and reporting patterns (themes) within data. It minimally organizes and describes your data set in (rich) detail."

Braun and Clarke (2006) provide a six step approach to conducting a thematic analysis of data that this research report utilized to form the basis of the analysis.

1. Become familiar with the data
   Familiarity with the collected raw data allows for immersion into the topic of study which is vital for more accurate selection of major themes

2. Generate initial codes
   Look to select and generate as many major themes as possible. Broad and slightly off topic themes will help offer richness to the data and offer perhaps unthought-of or unforeseen patterns. Filter through these primary choices in order to start further investigation into more aligned themes.

3. Search for themes
   With the initial list of themes selected, search through all the data in order to locate these themes in the different contexts. This allows for theory-based themes to be brought to the surface or put aside as the presence or absence of themes becomes apparent.

4. Review themes
   Consolidate the findings of the search with the initial list of themes and thoughts to analyse the direction of the themes and the relation of those to the research questions concerned. This allows the researcher to focus the main themes of the data in relation to the report.

5. Define and name themes

   Establish a defining categorisation of the theme and thus name it accordingly. Once a name and defining characteristics have been formalised, some data may either fall into or fall out of the category, thus refining the accuracy of the findings, and therefore the validity of the report.

6. Producing the report

   Align the named themes with the purpose of the report and research questions, in order to form a valid and credible conclusion to the data analysis.

This provided an extra level of data analysis that opened the data up to possible unforeseen findings.

3.6 Compliance with Ethical Standards

I recognized that before any research took place, I needed to obtain ethical clearance from Wits University which was granted. I also applied to the Department of Education for permission to conduct my study within the chosen high schools. With regards to the school itself, I spoke to the different principals of the high schools in order to give them information about the study and then received permission to proceed. This was done through face-to-face meetings and the use of a letter of information and request.

I informed the potential participant educators of the intended observation and interview, as well as the purpose and methodology of the study and then asked for his/her informed consent. Even though learners were not the direct focus of investigation in this study as the focus is on ML educators, learners were present in the classroom during lesson observations. For this reason, I informed both the learners and their parents or guardians as the target age was between 15 and 17 years of age. For all parties involved, assurances of anonymity and confidentiality were given, as well as procedures for the collection, storage and disposal of audio recordings.

For all information and consent form exemplars, as well as the Ethics clearance certificate from the University of the Witswatersrand, please see Appendix A.

These steps were taken to ensure that the key principles of validity and trustworthiness are present in order to mitigate as far as possible, the researcher bias of the study.

3.6.1 Validity

Killen (2003) describes validity as:

"… a unitary concept that refers to the "degree to which a certain inference from a test is appropriate and meaningful."

In essence, it refers to whether the conclusions presented from a research report (or any study) are sufficiently aligned and generated from the data findings and analysis of that report. In this study the use of two data analysis pathways i.e. a primarily deductive approach drawing on the PLM framework and a primarily inductive approach utilizing thematic content analysis, positioned the study to present conclusions that can be considered valid.

3.6.2 Research Bias

According to Norris (1997):

"Research whether quantitative or qualitative, experimental or naturalistic, is a human activity subject to the same kinds of failings as other human activities."

Research bias takes into consideration the impact the human element of the research process including (but not limited to) the ability of the researcher, the personal qualities of the researcher, and the researcher's academic cultural heritage. Through the acknowledgement and self-critique of the researcher's predispositions, while research bias cannot be completely removed, its impact can be reduced.

3.6.3 Trustworthiness

Guba's model for assessing trustworthiness will be used for this study. As discussed in De Vos (1998), there are four criteria for trustworthiness.

- Truth Value
- Applicability

- Consistency
- Neutrality

Truth value refers to the confidence of the researcher that the findings from the study are true. By taking an in-depth qualitative and explorative approach, the answers received during the interview and observations viewed allowed for a good level of confidence in the findings of this study.

Applicability refers to the degree to which the findings of the study can be applied into different contexts. This study is contextual in nature and so the results can be applied to similar contexts, but perhaps not generalized to the wider population.

Consistency refers to the studies ability to be utilized and replicated into similar contexts, and thus a clear and precise outline of the research methodology needs to accompany the findings. This chapter has attempted to illuminate the research methodology.

According to De Vos (1998) neutrality refers to the "degree to which the findings are a function solely of the informants and conditions of the research and not of other biases, motivation and perspectives." This study focused on the genuine responses and actions of the subjects within a specific context. As such, the degree of neutrality is intrinsic.

With all four aspects covered, this study can be deemed to be trustworthy.

3.7 Conclusion

This chapter has introduced the main focus of the study as analyzing the pedagogical practices of ML educators working with the CAPS curriculum. It has indicated the process in which the data was collected and analyzed with all possible ethical considerations made. The observations and interviews were used together to establish a deeper understanding of the process of linking the scientific concepts given by the CAPS document to the pre-existing structures and everyday concepts of the learners through the lens of PLM. The next chapter will show the collected data and offer an analysis of it. From this analysis, current patterns, key problems, and/or effective pedagogies explored and discussed to produce a more complete picture as to the nature of these phenomena.

Chapter Four: Data Analysis

4.1 Introduction

In order to address the aim of the study to explore ML pedagogical practices, as discussed in Chapter Three, the data collection process included three main sources. The first being from observations of three lessons of each of the three participant teachers. The second being data gathered from post-observation interviews for each teacher. The third is a caparison and contrast between the pedagogical practices observed and the indications put forward in the ML CAPS document. The analysis of the collected data will be initially conducted along two channels. The reason for this being that through the use of both deductive and inductive approaches the limitations of each shall be minimized. The first channel will use a deductive approach utilizing Pedagogical Link Making (PLM) – the conceptual framework of the study. A deductive approach, as discussed by Trochim (2006), moves from the general to the specific, which involves working from the theory to create a hypothesis, which is then, through observation, either confirmed or not. The main weakness here is the looking at instances through a specific lens, which will impact any observations. In this case, PLM is the theory that is used to generate a base of comparison for the observation of the educators. Here the use of Approach one, two and three demonstrated by the different teachers during the observations will be discussed and analyzed, highlighting the use of conceptual links within the lessons. The discussion will also include relevant insight gathered though the post-observation interviews in order to add a further dimension to the analysis such as reasons for pedagogical action. The referencing of the educator interviews will be in the form of an Educator Response Number (ERN) which can be viewed in the interview transcription in Appendix B.

The second channel takes an inductive approach utilizing thematic analysis as described by Braun and Clarke (2006). An inductive approach moves from a specific instance into a generality (Trochim, 2006), with its main limitation being the relevance and validity to the data. This channel of inquiry attempts to identify patterns in the data in order to discover potential themes that lie outside of the PLM framework, yet may add insight into Mathematical Literacy pedagogical choices and practices. The data from the observations will be utilized, but it is the post-

observation interviews that will be the main source for this channel as the perspectives given by the teachers are probed further through unscheduled, follow-up questions and answers. This will then lead to thematic findings of the data. Once both channels have generated insights, the analysis will continue with an integration of these points. Through this cross analysis, the main findings of the research can be drawn out, supported, and strengthened. The third tier of analysis will then be introduced. The findings generated from the two channels and the cross-analysis will then be compared and contrasted with the purposes, regulations and outcomes provided by the National CAPS document for ML (Department of Basic Education, 2011b). Figure 4.1 illustrates the flow of analysis.

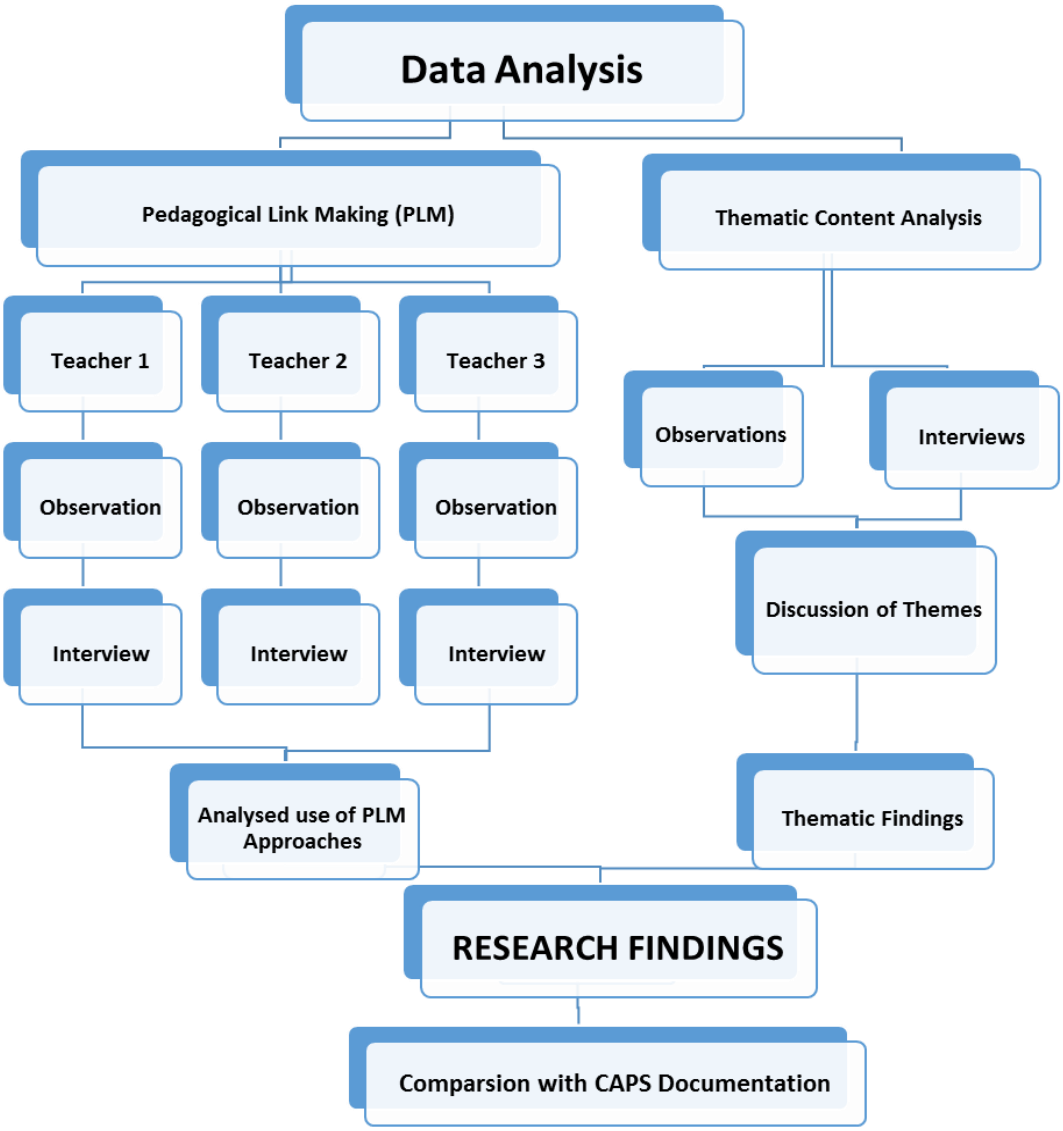


Figure 4.1: Visual Outline of Data Analysis

4.2 Observation Descriptions

The three participants (Mrs. A, Mr. B and Ms. C) were each observed over three consecutive lessons of Grade 10 ML, with the focus being on how the educators negotiated the linking of concepts in order to generate understanding in the learners. A more detailed description of the observation can be found in Appendix B.

4.2.1 Mrs. A

Mrs. A covered the topics of area and perimeter of basic shapes for the first two lessons. The first lesson was an introduction to area and perimeter that started with explanation of the main concepts. Then Mrs. A took the learners through some worked examples before giving them some questions to complete themselves. This was the general sequencing of the three lessons, but the second lesson included more time to work individually. The second lesson introduced some more complex questions which the learners had to work through. The third lesson introduced the topic of Pythagoras Theorem which elicited more explanation and guidance from the educator before giving the learners an individual exercise.

4.2.2 Mr. *B*

Mr. B covered the area and perimeter of polygons and irregular shapes. The first lesson introduced and focused on polygons, with the irregular shapes being introduced and worked through in the second and third lessons. A similar sequence of explanation of concepts followed by guided examples and then individual work was seen, however, in the second and third lessons Mr. B spent a greater proportion of the lesson on guiding learners through examples. The third lesson was a direct continuation of the second lesson and so there was no introduction to new topics but rather a refocusing of the learners onto the work before entering into more worked examples.

4.2.3 Ms. C

Ms. C covered the finance topics of statements and tariff systems in the three lessons. The first lesson worked with financial statements: how to read them, terminology, and how they relate to spending. The lesson had a far longer period of

introduction and explanation before moving into guided examples and then giving the learners an exercise to do. The second lesson introduced tariff systems, followed by guided examples and then individual work. The third lesson was a direct continuation of the second lesson and as such no introduction was used but rather the use of refocusing instructions was seen. However, during the lesson, the use of graphs in relation to tariff systems was introduced and added to the current exercise. The learners then continued working on the tariff exercise before Ms. C went through the answers with them in the last part of the lesson.

4.3 Pedagogical Link Making (PLM)

The PLM lens that is utilized in this analysis focused on the first three of the seven approaches provided by Scott et. al. (2011). Approach one focusses of making links between everyday and scientific ways of explaining concepts. The second approach (Approach two) discussed making links between scientific concepts within the subject context, and the third approach (Approach three) focuses on making links between scientific explanations and real world phenomena. Each teacher was observed over a period of three lessons with specific attention to the use of links in the pedagogical practices of the teacher. The links were observed in reference to the three approaches. Here we discuss the different approaches and how they were used by the three educators. This will incorporate not only data from the observations, but also some data from the post observation interviews.

4.3.1 Approach one

Approach one involves making links between scientific and everyday ways of explaining. This was most commonly viewed when the educators explained a concept using the ML specific terms and definitions given by the national CAPS document (2011a) and CAPS approved text books, and then using more everyday language with a follow up explanation. The link then takes place between the scientific explanation and the everyday explanation which the learner then uses to facilitate better understanding through the bridging of the ZPD (Vygotsky, 1978). This approach tended to be most prominent during the introduction or explanation of a new concept. It was then reiterated during individual questions and answering by the educators.

An example of this was from Mrs. A when describing a diameter of a circle. She used the following scientific explanation:

"Diameter is a line segment that passes through the center of the circle and touches the circumference at opposite points."

And then followed this up with this more everyday explanation:

"… the line that goes all the way through the circle."

Once this was used, Mrs. A tended to refer back to the everyday explanation when answering questions from the learners.

Another example, this time from Ms. C, occurred when explaining how to read a financial statement. She first describes the "opening amount" concept as:

"…the amount brought over from the previous statement."

She followed this with an everyday explanation of "opening amount" as:

"…how much you have or owe at the start of the time period."

A key aspect of this approach seemed to be the specific use of language and words to convey meaning. The particular scientific concept being discussed is described and discussed using words and terminology from the particular topic in focus, or other topics in the ML curriculum. The educators then substitute the more complex or difficult terminology with more everyday words and explain the concept again in a more everyday fashion.

The example by Mrs. A illustrates this through the substitution of the word "line segment" with "line". In mathematical terms there is a conceptual difference in the definition of a line and a line segment:

"Line Segment: A straight line which links two points without extending beyond them." ("Math Open Reference," n.d.)

"Line: A geometrical object that is straight, infinitely long and infinitely thin."

("Math Open Reference," n.d.)

Yet the everyday word of line is used to describe any visible linking – generally a straight one – between any two or more points of reference. So when Mrs. A provides an everyday explanation she removes the scientific term of a line segment and replaces it with the everyday understanding of a line in order to facilitate the understanding of the greater concept of diameter.

There does seem to be an issue with this approach. According to Vygotsky (1978), one of the fundamental parts of assisting learners in bridging the Zone of Proximal Development (ZPD), an educator would need to facilitate understanding of more complex, scientific concepts through generating an understanding and competence of the learner to distinguish more complex scientific concepts. If an educator focuses on explaining a grander scientific concept such as diameter while negating a lesser scientific concept such as line segment, does this facilitate learning more completely or more superficially?

A slightly different way that Approach one presented itself throughout all observations from all three educators was, again, in the use of explaining concepts, however rather than it being used during "translating" a scientific definition into an everyday one, it appears through the use of everyday language and gestures when explaining answers to learners. The use of the word "this" and "that" accompanied with pointing at numbers and/or operations and/or scientific terminology. The reason this falls under Approach one is that the educators are linking the scientific concept that has been explained already and instead of reiterating it, are using visual cues and everyday language to link the current thinking to the scientific concept.

Table 4.1 below highlights some of the examples of this from all three of the educators:

Table 4.1: Examples of the use of Approach one from Participants

Scientific Explanation	**Everyday explanation (accompanied with gestures)**
"The area of the circle subtracted from the area of the square"	*"The area of the big shape minus the area of the small shape"*
"the variable needs to be moved"	*"This letter needs to go here and hand here…"*

"a hexagon 6 equal sides	*"… this line is the same as this line, and this one, and all of them."*
"calculate the perimeter of the following shape…"	*"that side plus that side. Times it by 2…"*

During the observation it is clear that the link the educators are trying to make is between the work learners are engaging with and scientific concepts, but it is through the use everyday explanations albeit of a slightly different nature. These types of links where most prominent in the individual work sessions during the lessons, as the learners would ask for assistance with a question and the educator would look at the work done, analyze it, and then give guiding assistance in linking the work of the learner to the specific scientific concept required.

Ms. C used this approach the most out of the educators. When asked about the use of everyday language in the explanation of concepts she discussed how the learners struggle with multiple scientific concepts and so she tries to *"make it as simple as possible."*

"I guess, a lot of them – even if they have heard the word opening balance – the think "what does that really mean?" So I do – I don't want to say dumb it down – but I do make it as simple as possible, words they have used. Sometimes they have heard words from the textbook but they haven't actually thought of what it means."

(Interview Transcriptions, ERN 113)

From this, Ms. C uses the everyday language as a substitute to more complex terms to avoid using too many scientific definitions at once. The reason for this was to facilitate understanding of the current concept and maintain focus on this understanding, however, she does make the admission that this is a weakness in the learning process:

"I think that may be a bit harsh on them but it really is the reality. They are not going to go over vocab. They might go over a concept like a bar scale, but they are not going to – if I ask them for a definition, they will never be able to give me a relevant definition." *(Interview Transcriptions, ERN 113)*

Another reason for the increased tendency to use of everyday language and explanations is due to current academic ability of the class. Ms. C makes a point that due to the variety of levels of academic ability in her class, there are some learners that struggle with reading and raised the possibility of reading and language barriers as some of the learners are not English home language speakers. Through the repetition of everyday language and words, Ms. C hopes the learner will develop an ability to automatically recall the concept to help understanding during tests. That the learners have *"…heard it enough times to know automatically what it means in real life." (ERN 113).* In other words, Ms. C is not only trying to facilitate understanding of a mathematical concept, but also trying to generate an understanding and linking of English words.

4.3.2 Approach two

Approach two is making links between different scientific concepts within the subject context in order to facilitate understanding. The links take place between the different concepts provided by the ML curriculum as well as those general mathematical concepts that have been taught at previous levels of education. The thinking around this is that in the process of generating understanding within the learner of more complex scientific concepts, learners require knowledge of or understanding of prior-learned concepts, or less complex concepts, or other scientific concepts that are learned in tandem with the current topic. With the link then made, the learner then becomes more familiar with the desired concept. This approach was most commonly used during questions and answering sessions with the educator and during individual or group work.

Table 4.2 below shows some of the examples across all three educators. Again, it tended to arise when learners asked questions about the given work and how to solve a problem. The educators would then refer to different concepts to help the learner come to a solution.

Table 4.2: Examples of the use of Approach two from Participants

Scientific Concept in focus	Other Concepts that were linked
The perimeter formula for rectangles P = 2L + 2B	Algebraic substitution
Perimeter of polygon calculation	Definition of a polygon
Working with formulae	Fraction conversions
Total due on Statement	Decimal / fraction conversions
Tariff calculation	Rules of Equations
Rate calculation	Time Conversion

The table highlights the use of other mathematical or ML concepts to help support the understanding of the desired concept. In the first example, the educator made reference to the rules of algebraic substitution which is part of the Grade 8 and 9 Mathematics curriculum to help a learner with doing the perimeter calculation. Perimeter was the focus of the lesson. During the tariff calculation lesson, the educator had to go over the rules of equations, again concepts that have been dealt with in prior Grades or lessons.

It was interesting to note that over all nine lessons with all three educators was that Approach two was used the most out of the three approaches. A possible reason for this came from the post observation interviews. When asked about the use of using other ML concepts in a lesson, Mr. B said that this was because of "reiteration" (ERN 61). He discussed how he sees that the learners struggle to deal with multi-concept problems and as such helps them by reiterating some of the concepts that they may forget about or not think of:

"Single concepts they can handle. Mixed concepts and different concepts together all mixed up they just cannot handle. So when we do one concept I remind them that a circle is not just about the circle that we are looking at but there are other things underlying, to get to where you want to be with the circle."

(Interview Transcriptions, ERN 61)

Mr. B goes on to stress just how important reiteration of prior learned concepts is in his pedagogical practices:

"I can bet you now that in 3 weeks' time, we can ask these same questions again to them, they will not have remembered them unless I have reiterated them every single time."

(Interview Transcriptions, ERN 62)

The repetition of concepts is widely accepted across education sectors as a fundamental aspect of improving understanding and knowledge. Thalheimer (2003, p. 10) stated just how important repetition was when he stated:

"Repetition is arguably the most important learning factor, typically improving performance by 30 to 110% for initial repetitions and by 15 to 45% for additional repetitions."

As the learner engages with a concept repeatedly, the fluidity of thought surrounding the concept becomes smoother and the learner is better able to access that information when engaging with more complex concepts. Mrs. A also makes reference to reiteration when she was asked why she kept going back to an analogy (covered in approach three) she had made about perimeter:

"So you will have to remind them constantly "remember to use this, remember to use that," because as soon as you start to do one extra concept then some of them are very confused."

(Interview Transcriptions, ERN 21)

Ms. C highlights the importance of repetition in her class as a way for a concept to *resonate* with the learner:

"Not all kids are listening every single time you say it. … So if you ask it again, obviously you weren't listening the first, second or tenth time I said it and hopefully this is the time it will resonate with you."

(Interview Transcriptions, ERN 117)

The finding that Approach two was used the most over the nine lessons certainly reemphasizes the importance educators place on reiteration when generating understanding in the learners, however it is not just a matter of remembering a singular concept and then another singular concept, but rather how the previously learned concepts relate to the concept(s) being learned at the moment.

4.3.3 Approach three

Approach three focuses on making links between scientific explanations and real world phenomena. This link differs from Approach one in that the concept is not linked to everyday words or an everyday explanation, but rather a link from a working everyday or common scenario to a scientific concept or system of concepts. It is the process of liking a scientific concept to an experience had in real life. This is distinguished from an analogy by Scott et al. (2011) through intention. Approach three has the intention to utilize the link to the real world in order to generate deep conceptual understanding, while an analogy does not necessarily require a conceptual link. The instances observed during the lessons were taken as Approach three instances due to the linking towards the development of a concept.

There were three main links to the real world observed over the nine lessons, which were restated at later times in the lessons to aid with reiteration. The first was from Mrs. A in a lesson focusing on perimeter calculations. She linked the situation of a man walking around a fence with scientific explanation of perimeter of different shapes. The analogy was to think of a man walking around the boundary fence of a property and the distance he walked was the distance of the perimeter. When asked about this analogy Mrs. A discussed how the learners tend to get very confused with perimeter and area, and so by mentioning the “fence” analogy, the learner better understand the concept of perimeter being the surrounding lines only and not added to any other lines inside the shape:

“Like on a tennis court, if you ask them to work out the perimeter it means just the outside. That is where you are going to put the fence, not on the lines that have been painted inside the tennis court to show the different sections of the tennis court.”

(Interview Transcriptions, ERN 20)

She used this in four recorded instances; once in a general explanation to the class and then a further three times during individual questions and answers. Another instance of the *man walking around a fence* explanation came during an explanation of the distinction between circumference and perimeter in a semi-circle and a quarter circle. Again, the findings point to the importance of not only creating an effective link to a real world scenario, but also in the reiteration of it to help cement the concept.

The next main analogy was used by Mr. B in his lesson which was focused on the area and perimeter of irregular shapes. He was discussing the difference between area and perimeter and then started to tell a story about how, when he was a boy growing up, he lived through the evolution of computer game graphics. He talked about how games had started in one dimension, then moved into two dimensions, and now how games are being played in three dimensions. When the story was finished he then linked the increasing levels of complexity to perimeter (one dimension), area (two dimensions) and then volume (three dimensions). He then referred directly to the general formula for all three concepts while repeating aspects of his story.

When asked in the post observation interview, Mr. B discussed how the reason for this was to keep the concepts in focus while building a relationship with the students. He used the computer game topic specifically for his all male class as he felt that the story was something the learners could relate to.

"With the girls class I wouldn't have done that. With the girls class I would have, you know, had a look at a different approach. But with the boys' class, sport, computer games and things like that [they] like."

(Interview Transcriptions, ERN 63)

This reasoning from Mr. B illustrates that the motivation of the story was not just to help learner understanding but also to relate to the learners on a personal level. This reasoning speaks to the third form of PLM (Scott et al., 2011). This form gives the reason for PLM as encouraging emotional engagement from the learners. Mr. B used the story to link the concepts of perimeter, area and volume and the increasing complexity of computer games in order to support the building of knowledge within the learner, and also to elicit a positive response from the learners to engage with the concepts.

The third real world scenario was again by Mr. B, although the instance had two different links to emphasize the same point. The point was to that the learners needed to only round off when the final answer is calculated. He first made reference to when learners bought sweets at a shop and the shop clerk did not give back the 50 cents. He asked the learners if they would take note of that and ask for it. This emphasized that even though the amount of money is small, it still makes a difference. This was then linked to the importance of rounding correctly in mathematical calculations. The second part of the link he discussed how engineers, when building a house or bridge, need to be extremely accurate with their measurements and rounding, as the smallest discrepancy in calculations could result in the structure being unstable. Again linking it to the importance of accurate rounding.

When this was discussed in the post observation interview, Mr. B explained why he particularly used the shop analogy:

"You know finance is easy to relate because everyone has finances so usually when we talk about … "when you guys go to the shop." And you can relate that because everyone has bought something from a shop…"

(Interview Transcriptions, ERN 59)

Due to the common nature of buying from a shop, Mr. B was making sure that the link to the real world was effective. He also mentioned that some examples do not have the same effect because not all of the learners have experienced that real world process, or the process is not something they have thought about.

"Like soccer and rugby and sports and running... talking about measurements, the dimensions of a soccer field and measurements of the goal posts. You have a look at area, and surface area, and perimeter and things like that, and it immediate relates. "I like soccer. I know exactly what the post looks like." But if you now go and relate it to a building for instance, it's not quite the same connection. It's not the same connection at all."

(Interview Transcriptions, ERN 60)

The main use of approach three links was observed at two separate parts of the lesson. The first was in the introduction of concepts, generally at the beginning of the lesson. The second place was in the lesson when there was the escalation of complexity of a concept or of exercise questions.

4.3.4 Insights into the use of Pedagogical link making

The finding was that all three educators used all three approaches throughout the three lessons, however there were tendencies to use approaches one and two in more observable instances than approach three. Figure 4.2 illustrates the usage of approaches throughout the nine observed lessons. Over all the observed approach two had the most observed instances with 56, while approach one and three had 43 and 39 respectively. While a variety of concepts were related to the current concept in focus, there was also a strong usage of reiteration of links throughout the lessons – particularly when using approach two. When approach three was used it formed a substantial aspect of the focus of the lesson, while approaches one and two were used more commonly without requiring focused attention from the class as a whole, but rather through individual engagement.

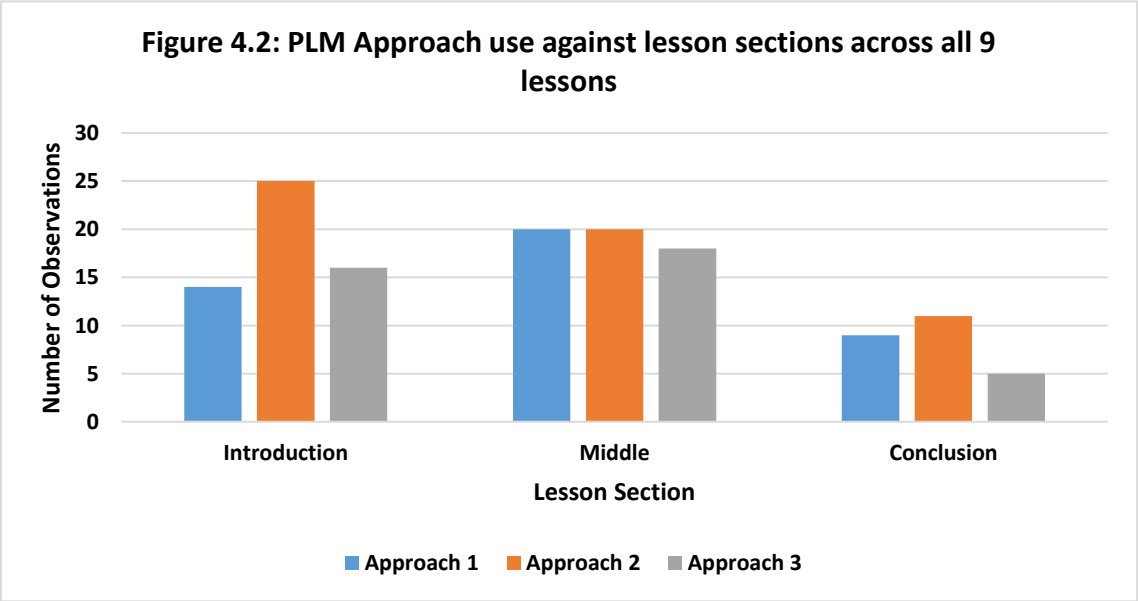


Figure 4.2: Approach Usage

There were also observations of the other PLM forms observed during the lessons. The emphasis on building relationships with the learners, was discussed in the interviews with the main reason being to drive learner motivation to engage in the

work and learning processes. From the observations there seemed to be a pattern of usage for all three approaches when relating it to the complexity of the concept being taught (Figure 4.3 is a visual representation of this). To clarify, the complexity of a concept according to Vygotsky (1978) ranges between specific, concrete concepts that are ingrained in everyday activity to very abstract concepts that are general and removed from specific contexts. It appeared that educators tended to use Approach three during introductions of concepts, and then again when more complex problems or multistep problems were being worked on. Approach one and two were used throughout the lessons but seemed to be focused on during learner engagement with the current concepts in focus. Figure 4.3 is a graph that illustrates the tendency of educators using the approaches as the complexity of concepts increase as observed in the lessons. The first pathway of data analysis followed a tight focus on the use of PLM in the observed lessons. Next, a broader perspective is taken in the thematic analysis.

Figure 4.3: Graphical representation of observed pattern of approach usage in relation to concept complexity

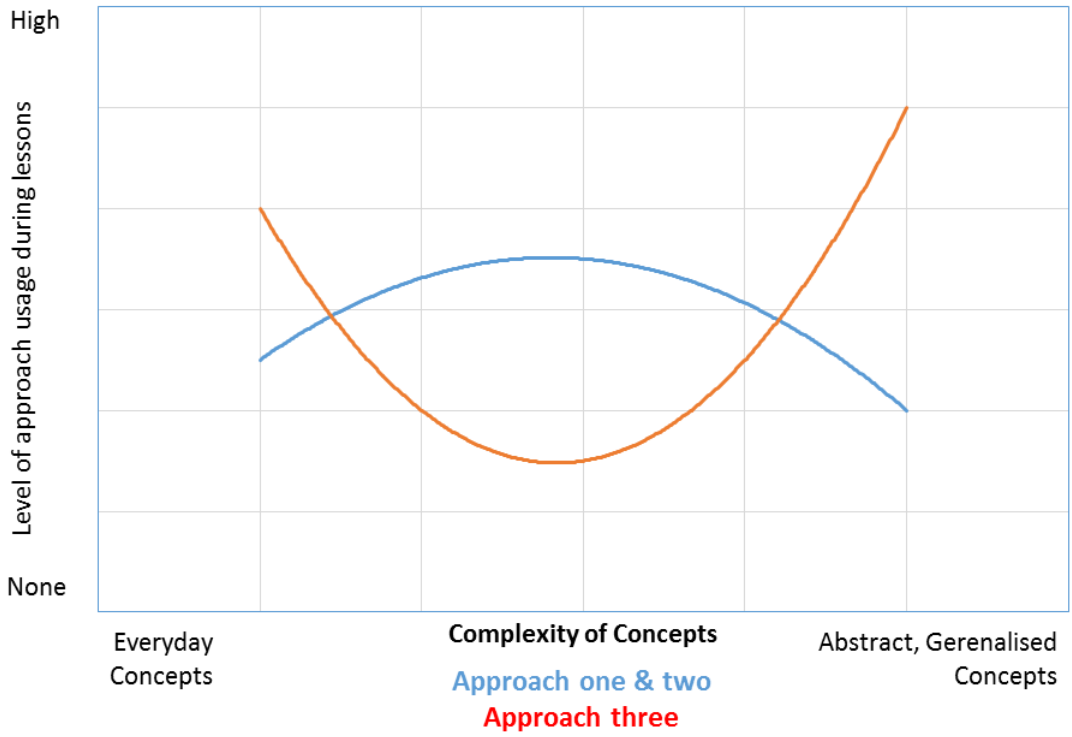


Figure 4.3: Illustration of Approach Observation

4.4 Thematic Analysis

Having discussed pedagogical practice utilizing PLM as a lens, attention is now turned to undertaking a thematic analysis of data in an attempt to uncover relevant emergent themes. As indicated in Chapter Three, the thematic analysis used for this discussion is provided by Braun and Clarke (2006), specifically their six step approach.

4.4.1 Familiarization with the data

The first step is to become familiar with the data. This has happened through the observation process, the post observation interviews and the analysis of PLM above. The interview schedule was divided into 3 broad sections. The first was teacher experience and qualification. The second was questions on ML specifically. The third was for observation reflections where questions that arose during observation could be discussed with the individual participants. Table 4.3 below provides an example of the interview transcript of the post observation interviews. As stated previously the ERN stands for Educator Response Number which was used for ease of reference and coding.

Table 4.3: Example of interview transcript taken from Part 1: Teacher experience and qualifications

INTERVIEWER	ERN	PARTICIPANT
What subjects do you currently teach (or have taught)? Are you qualified in all of them?	**4**	Mathematics from Grade 8 up to Grade 12, and maths literacy Grade 10 and 11 and currently also teaching EMS for Grade 8s.

4.4.2 Generating Initial Codes

The second step according to Braun and Clarke (2006) is to generate initial codes by systematically coding and identifying common or repeated features in the interview transcript. The following tables (tables 4.4, 4.5, and 4.6) highlight the initial coding for the three educators. Here are examples of each educator. For the full tables, see Appendix B.

Table 4.4: Initial codes for interview with Mrs. A

Code	Example of occurrence	ERN locations
ML for learners who cannot do or struggle with Mathematics	*"…you need to give a bit of maths to kids who cannot do the pure maths..."*	14, 14, 14, 20, 20, 20, 21, 22, 30, 33
ML focuses on the everyday situations and knowledge	*"We focus more on everyday situations like when you have to measure a table to see if its going to fit through a door…"*	13, 13, 15, 18, 20

Table 4.5: Initial codes for interview with Mr. B.

Code	Example of occurrence	ERN locations
ML for learners who cannot do or struggle with Mathematics	*"Single concepts they can handle. Mixed concepts and different concepts together all mixed up they just cannot handle."*	49, 49, 57, 61, 64,
ML focuses on understanding concepts. Understanding the why.	*"…try to understand why do we measure? Why do we have a length? Why do we have a breadth?..."*	47, 57, 58, 61, 67,

Table 4.6: Initial codes for interview with Ms. C.

Code	Example of occurrence	ERN locations
ML is about application of concepts	*"I think it's a real life application of maths."*	90, 91, 116
ML focuses on the everyday situations and knowledge	*"I think its definitely a practical application where you use certain information more in your everyday life."*	91, 97, 97, 115

4.4.3 Searching for themes

Braun and Clarke (2006) suggest that the next step is to search through the initial codes in order to establish common trends or instances within the data. From the coding tables for the individual teachers, the codes were compared and contrasted against each other. Table 4.7 shows the combined codes from the three educator interviews. The colors are used to highlight similar themes.

Table 4.7: Initial codes from all Participants colored to indicate similar themes.

Mrs. A	Mr. B	Ms. C
ML is about application of concepts	ML is less complex than Mathematics	ML and Mathematics are different subjects in principle
ML for learners who cannot do or struggle with Mathematics	ML for learners who cannot do or struggle with Mathematics	ML is about application of concepts
ML focuses on the everyday situations and knowledge	ML focuses on understanding concepts. Understanding the why.	ML focuses on the everyday situations and knowledge
Use of examples to highlight an answer by educator during the interview	Use of examples to highlight an answer by educator during the interview	Use of examples to highlight an answer by educator during the interview
Educator learning ML through experience	CAPS instruction is not in line with common practice in teaching ML	Educator learning ML through experience
ML learners struggle to focus on work	Educator learning ML through experience	ML learners lack motivation to engage with the work
Keeping learners motivated and interested	ML learners struggle to focus on work	Discipline problems
Relating concepts to the learner through examples	Keeping learners motivated and interested	Relating concepts to the learner through examples
Linking concepts with previously learned concepts	Relating concepts to the learner through examples	Linking concepts with previously learned concepts
	Linking concepts with previously learned concepts	

4.4.4 Review Themes

The themes are then to be analyzed and reviewed in relation to the research questions of this report, namely in what ways educators address the link between scientific and everyday concepts in the classroom and in their pedagogical practices. The initial themes can then be grouped into broader themes for further discussion. From this we can move onto the next step.

4.4.5 Defining and Naming Themes

Through the reviewing of the themes and the grouping, the main themes from the data can be defined and named. Table 4.8 illustrates this process resulting in the main themes of the prevailing perspectives of ML, the motivation and discipline of learners, and educator training.

Table 4.8: The reviewing, defining and naming process

Initial Codes	Group Definition	Theme Name
ML is about application of concepts	This group gives insight into how the educators view ML as a subject separate to Mathematics and to ML as a subject in general.	**Prevailing perspectives of ML**
ML for learners who cannot do or struggle with Mathematics		
ML is less complex than Mathematics		
ML and Mathematics are different subjects in principle		
ML focuses on the everyday situations and knowledge		
ML focuses on understanding concepts. Understanding the why.		
ML learners struggle to focus on work	This group gives insight into the pedagogical experiences of the educators, their engagement with the learners, and some of the main issues with teaching a ML class.	**Motivation and discipline of learners**
Keeping learners motivated and interested		
Discipline problems		
Relating concepts to the learner through examples		

CAPS instruction is not in line with common practice in teaching ML	This group speaks to the feeling of the educators and the training or instruction they received prior to having to teach ML.	**Educator Training**
Use of examples to highlight an answer by educator during the interview		
Educator learning ML through experience		

4.5 Discussion of Themes

The purpose of this report is to study the pedagogical practices of ML educators through the lens of PLM (Scott et al., 2011), but with the thematic analysis the boundaries of observation from PLM can be removed and broader observations can be discussed. With this in mind, three themes have been identified:

1. Prevailing perspectives of ML
2. Motivation and discipline of learners
3. Educator training

4.5.1 Theme one: Prevailing perspectives of ML

According to Botha (2011, p. 20):

"… many people outside the academic field tend to believe that only basic mathematical skills are involved, or that numeracy refers only to primary school learners' Mathematics."

Botha goes on to say that ML is not that simple and requires a more developed and distinct definition. The prevailing perspective from this is that ML is a lesser subject than Mathematics, which holds particular implications to the academic level of the learners who take the subject. This perspective of ML was observed during the educator interviews.

When asked about the purpose of ML, Mrs. A responded that it was there to provide the *"… kids who cannot do pure maths…" (Interview Transcriptions, ERN 14)* with some mathematical practice. Mr. B responded in a similar matter when asked the same question in that the purpose of ML was to aid learners who cannot cope with pure Mathematics *(Interview Transcript, ERN 49).* The nature of these answers highlights that both educators define ML through a mathematical lens, and then

through the language used strongly implies the lesser status of ML as a school subject.

Ms. C offered a different response to the purpose of ML. She said that ML was a subject "…*that helps people with their everyday lives. You are almost training them to be able to do basic skills better" (Interview Transcriptions, ERN 97)*. The subtle yet profound difference in her response was that Ms. C viewed ML as an entirely separate subject from Mathematics, in fact, in her entire response to the question she didn't mention ML in relation to Mathematics once. However, while offering a more separated response to the purpose of ML, the lesser connotation to subject of Mathematics arose in responses to other questions.

This was observed in the language of the responses by all the educators at various points during the interviews. The language used to answer the questions very much implied that ML was an inferior subject to Mathematics, and subsequently the learners far inferior to those of Mathematics in academic ability.

Mrs. A's response to a question on why she used a particular real world link during a lesson indicated her belief that the level of ability of the learners was poor.

"… you really have to make it easy, easy, easy for them otherwise they are not going to understand, because there is a reason why they don't continue with pure maths in Grade 10 and why they took maths literacy."

(Interview Transcriptions, ERN 20)

Another example of this occurred in the very next question about the use of repetition of Approach 3.

"Because they are very easily distracted, you know, so if someone talks to them then they will forget about what they actually need to do. There really is a reason they are sitting in Maths Literacy class."

(Interview Transcriptions, ERN 21)

Mr. B showed his perception of ML more directly when asked to describe ML:

"To me it would be a watered-down effect from pure maths…"

(Interview Transcriptions, ERN 46)

Ms. C was more conscious of using her words to describe ML during her interview, but there was evidence that there was a recognition that there is a prevailing perspective of ML as inferior to Mathematics. When questioned about why she tended to use Approach 1 so often during her lessons, her response included:

"So I do – I don't want to say dumb it down – but I do make it as simple as possible…"

(Interview Transcriptions, ERN 113)

Here she was referring to the terminology and the language used during her lessons and explanations of concepts.

While maybe not directly stating that ML is a lesser form of Mathematics, the perception was fairly apparent through the language used in such instances. This perception of ML as a lesser form of Mathematics was rationalized by Mr. B through his experience with teaching ML in Grades 10, 11, and 12. He claimed that the syllabus for all three years was very much the same and that,

"… I can tell you now – that if you have a good Grade 10 group [they] would be able to do at least 60% of a prelim or final paper [in Grade 12]*…"*

(Interview Transcriptions, ERN 51)

This indicates that Mr. B believes the content of ML to be at a fairy basic level and as such feeds the perspective of ML being a lesser academic subject. These instances throughout the data support the statement made by Botha (2011) that there is indeed a tendency to view ML as a lesser form of Mathematics.

4.5.2 Theme two: Motivation and Discipline of learners

Another prominent theme that emerged from the interviews also spoke to the reasons for the pedagogical choices in the lessons. As opposed to basing pedagogical decisions primarily on knowledge building and concept development, all of the educators mentioned that the primary reason for most of their pedagogical decisions were based on eliciting positive responses from the learners in terms of

interest, motivation and discipline. All educators emphasized that achieving buy-in from the learners was a top priority while simultaneously conceding that this was a tough task in their ML classes. The discipline of the learners seemed to be a key problem area for the educators and thus played an influential part in their pedagogical decisions.

Mrs. A explained how easily it was for learners to get distracted during lessons when asked about her reasons for repeating an analogy during her lessons.

"Because they are very easily distracted, you know, so if someone talks to them then they will forget about what they actually need to do."

(Interview Transcriptions, ERN 21)

This is evidence to support the influence learner motivation, interest and discipline have on the pedagogical decisions of the educator. Here Mrs. A chooses to reiterate PLM approach 3 based on keeping the learners focused on the work.

A similar reasoning was given by Mr. B when asked about his use of Approach 3. The reason he gave for using real world links and analogies during lessons was to generate interest in the learners. He admitted that sometimes, analogies went off topic, but that this was a conscious decision as it then encouraged learners to get more involved in the lesson, before returning to the content. When asked directly if this was a tactic to generate learner discussion, Mr. B responded:

"You have to. Especially in my class. I teach an only boys class, and there, if you just get to the front of the classroom and say: "this is the work. This is what we are doing." Your tone of voice stays exactly the same – you are not going to get anywhere. But you got to relate to what they like… it immediately relates."

(Interview Transcriptions, ERN 60)

Yet again, evidence to support the influence of learner motivation in the pedagogical reasoning process.

Nowhere was this concept more apparent than in the interview and observations with Ms. C. When asked how she tries to generate understanding in her learners she replied:

"I think it is very difficult. My class – and I don't know if this is just my class – but my class seems to be very unmotivated. So as long as they come to class and I give them notes and they have an exercise to do and I mark it, more than that they really just don't cooperate."

(Interview Transcriptions, ERN 104)

As the follow up question, Ms. C was asked directly if motivation of the learners was a problem. She responded:

"Yes. Trying to actually get them to, you know, they battle to grasp… so for example, yesterday they had to read an instruction on how to change a washer in a tap and they just read the first word – they looked at washer – and thought "it must be a washing machine." So when I tried to explain to them: "No. There are different parts…" And it's not just one student being a pain, like general consensus is: "let us just do our work so that we can leave and not have homework."

(Interview Transcriptions, ERN 105)

The problem of discipline and motivation was such a problem that Ms. C had to get other educators in to help when her class "blew up" after some serious issues in the lessons including learners throwing books at her.

"I have had some serious issues and my class blew up and I had to get people in. Go over rules again and there was a whole lot of disrespectfulness, throwing textbooks at me."

(Interview Transcriptions, ERN 119)

Ms. C did reflect that the situation may have arisen from some wrong or misguided pedagogical decisions on her part, but again this emphasizes just how much ML educators focus on learner motivation and discipline in determining their pedagogical choices. Ms. C required outside help from the teacher executive to help curb the issue, but then had to change her pedagogy entirely. Rather than using more discussion, and explanations to the general group, the learners were given longer, individual tasks to complete during the lessons. Ms. C then used the approaches on a more individual level. This was used in tandem with the learners being allowed to listen to music.

This was one of the interesting ways that Mrs. A and Ms. C combatted the issue of focus, distraction and motivation. The learners were allowed to take out their head phones and play music from a portable device – most commonly a mobile phone – while they worked on a given, individual task. Both educators said that this was an attempt to get the learners who were disruptive or distracting to others to focus attention elsewhere while allowing those learners who did want to work space to do so. Ms. C said:

"… I think it works to help them with concentrating. … But it keeps them quiet so that the kids that are learning are able to learn without other people interrupting them."

(Interview Transcriptions, ERN 123)

Mrs. A supported this point when she was asked why she allowed the learners to listen to music in her lessons.

"With the kids today! They say they cannot concentrate or work without their music. Now I actually don't believe that because, even if I do a very difficult maths sum I cannot sit with music in the background. I don't like to learn like that, but all of them – across the board – go and ask them: they cannot concentrate without their music. And it's also a way to keep them quiet. It doesn't; you don't succeed every time and the kids today don't have work ethic so, it's everything to try and get them to work. So if they say they cannot do it without the music, I say "ok, listen to music but also do your work."

(Interview Transcriptions, ERN 24)

While the effects of listening to music on the taking in and understanding of concepts seems a debatable topic, both educators make clear that this pedagogical decision is not based on knowledge development or conceptual understanding, but rather based on getting learners to focus on their work and be more disciplined in class.

Another interesting way to address the issue of discipline and motivation of the ML learners was seen in the class composition. Mrs. A only had girls in her class, while Mr. B only had boys. When asked the reason for this Mr. B discussed how by removing the girls from the class, the boys had less distractions and were less inclined to misbehave. Both Mrs. A and Mr. B seemed to agree that it was easier to

get learner buy-in from single sex classes. While this is more of an administrative decision than a pedagogical one, the reason for it speaks directly to just how big a role ML learner discipline and motivation for learning plays in ML education.

4.5.3 Theme three: Educator Training

The last theme was termed Educator Training as there some commonalities with how the educators discussed introductions into teaching the relatively new subject of ML. As a starting point for this pathway of thought, all three of the ML educators' qualifications were not in ML. While Mr. B and Ms. C have education qualifications in Mathematics, Mrs. A does not and has a qualification in Natural Sciences. The obvious answer with Mrs. A and Mr. B was that they were got their qualifications before ML existed, but Ms. C got her BEd in Mathematics in 2012 – five years after ML was formally introduced in Grades 10, 11 and 12. However her degree focused on Mathematics in Senior Phase (Grades 7, 8, and 9) and ML is only taught in the FET Phase (Grades 10, 11, and 12). This meant that all three educators were moved into teaching ML from other subject backgrounds.

They were then asked about any training that they had when making the move into ML education, and there was a general consensus that there was little or no training about teaching ML. Even when a formalized training session were organized for the educators, all three emphasized that the majority of learning on how to teach ML was achieved through their own experiences.

Of the three educators, only Mr. B made mention that he had attended a governmental workshop with the purpose of educating educators in the new subject, however when asked if he found this workshop to be effective he said:

"Not at all. Not at all."

(Interview Transcriptions, ERN 44)

This negative perception towards teacher training in ML was further emphasized when asked about his familiarity and access to the current ML CAPS document which outline and guides ML education.

"I have it and I do have access to it. Do I implement it every single day I teach? No. Because there is a lot of waffle in between, which is… You've got to spend a lot of time on paperwork essentially and that takes so much time from our teaching that you don't get to teaching so now we put the paperwork aside and do the actual teaching time."

(Interview Transcriptions, ERN 55)

In the follow up to that comment, Mr. B was asked if he believed there was a difference between what the governmental officials believe should be going on in class and what he does in class. His response:

"Yes. Absolutely."

(Interview Transcriptions, ERN 56)

Ms. C did say that she had had an experience of teaching ML for a period of three weeks during one of the practical sessions of her Bachelor of Education in Senior Phase Mathematics, however, this was not a planned teaching practical for her to train in ML education. Ms. C said that she was supposed to be teaching senior phase Mathematics (Grades 8 and 9) but the mentor assigned to her taught the ML class and so Ms. C was asked to teach those. So even though she had some instruction and experience with ML during her qualification, it came about through chance rather than planned teacher education. Another chance experience with ML during her qualification was in her fourth year practical of 7 weeks, where a ML teacher was absent or sick and so she was asked to teach the class for the 7 weeks.

Mrs. A had the least exposure to ML teacher training. When asked if she had received any kind of training, Mrs. A replied:

"No, no. They just assumed because I am a maths teacher that I must be able to teach it. No Formal training. They just gave us the text books and teacher guides and said there you go, go and teach it."

(Interview Transcriptions, ERN 10)

Suffice it to say, there was a generally negative perception of the ML training or any education surrounding ML. This supports the findings of Sidiropoulos (2008) – as

discussed by Botha (2011) – that ML educators did not value and understand fully the ML curriculum. This could hold very real implications for the pedagogical decision making process of the educators. If the educators do not feel comfortable with the prescribed knowledge and practices of ML from the CAPS document, they will rely on their other subject experiences to determine pedagogical choices.

4.6 Overall Findings

4.6.1 Finding One: ML Educators utilize a variety of links in their pedagogical practices

It is clear from the data that each of the educators utilized all three of the PLM Form 1 approaches during each of their lessons. There was even indication of the use of other PLM forms. The educators gave similar reasons behind the use of each approach with the primary reason to generate understanding in the learners of the concept. There was evidence that each of the educators were able to use the different approaches at different times of the lessons, and even to use different approaches to emphasis the same concept in a different way. This indicates that getting the ML learners to understand a concept is a key concern in the pedagogical decisions made by the educators.

4.6.2 Finding Two: The type of link used is related to both the timing in the lesson and the complexity of concepts.

A pattern of approach usage was observed over all nine of the lessons. During the introduction phase of the lessons all educators used Approach three, and then, as the lesson progressed, Approaches one and two became more regular. This coincided with group exercises, answer explanations and individual work. Reiteration was used by all three educators throughout the lessons using the various approaches.

It was also found that the educators used Approach three to introduce a topic through relating concepts to real world application, then utilized Approaches two and three to help scaffold the learners to understanding the concept and answer increasingly difficult questions. Thus, the complexity of the concept (or group of concepts) influenced the educators' usage of approaches. This was best observed in

the increased use of Approach three when multi-concept problems were presented to the learners towards the end of the third lessons. Figure 4.3 illustrates the observed pattern in relation to the complexity of concepts.

4.6.3 Finding Three: The perception of ML by ML educators affects their pedagogical decisions and practices.

Two out of the three educators provided descriptions of ML as a lesser version of Mathematics. Only Ms. C believed that ML was a very separate and different subject to Mathematics, but even she indicated the belief that the academic level of the ML learners was lesser than those of Mathematics. This then seemed to play a significant role in the pedagogical decision making of the educators when it came to using links in the lessons. This was most evident in Ms. C's lessons where she tended to use Approach one links very regularly in her lessons. When asked about her increased use of everyday language when explaining concepts she pointed out that it was not only due to the belief of the low academic level of the learners but also a low level of ability in language. This link between the perception of a poor academic level of ML learners and link usage was again highlighted by Mrs. A throughout her interview. She indicated that she would have to use Approaches one and two regularly coupled with reiteration in order to generate understanding in her learners.

This highlights the impact that a perception of ML and the perception of the ability of the ML learners can play in the pedagogical decisions of the educators as well as the learning of the ML learners. As mentioned previously, in order to bridge the ZPD (Vygotsky, 1978) the learner is required to work with the scientific concepts at an increasing level of familiarity. If learners are less exposed to scientific terms and concepts through the educator's increased use of everyday language, this surely has a negative impact to the learners developing an understanding of a concept. Therefore, the perception of ML and, as extension, the ML learners by the educator is very significant in the effective teaching of ML as a FET subject.

4.6.4 Finding Four: ML Educators make pedagogical decisions based on generating learner interest

A very prominent finding from the data was that the educators made pedagogical decisions based on getting the learners interested in content, motivated to work, and to focus during working sessions. This was prominent in all three of the of the post observation interviews, none more so than in the interview with Ms. C. Ms. C discussed how she battled with her lessons while trying a number of different pedagogical ideas, but she found that the more successful choices were very much based on getting the learners to behave appropriately in the class. She was not alone in this as both other educators revealed just how much effort they put in to get the learners to engage and participate in the lessons.

An interesting finding was how each of them approached this in different ways. Ms. C required outside assistance from more senior educators to rectify the situation at first and then managed to improve the situation by giving more individual work and less general discussion. While Ms. C did use the different approaches, she did seem to prefer an approach for a section of work. Mr. B on the other hand took on a very structured approach with his learners. He controlled the participation of the learners by dictating the tempo of the lesson, engaging learners at a personal level, and changing the method of delivery quite quickly to keep the learners engaged in the lesson. He continually moved between PLM approaches to highlight the same point, which did seem to prove successful. Mrs. A had a more relaxed pedagogical approach to generating to learner interest. She preferred to keep a standard flow of the lesson with an introduction, group instruction and then individual work. The learners seemed to respond as they were aware of how the lessons tended to progress.

The interesting observation of how to generate motivation and focus in the learners came from Mrs. A and Ms. C. Both educators allowed learners to listen to music on the learners' personal music devices during the individual work sessions. When questioned about it, both educators discussed how the main reason for this was to keep the learners quiet, working and not distracting other learners. While neither educator was sure of the academic or cognitive effects the music had on the learners, both were happy if the learner did appear to be focused on work. These

were blatant instances of pedagogical decisions being based on learner involvement and behavior.

The evidence of the significance of learner interest and motivation was not only prevalent in the classroom, but also reached into management decisions. Mrs. A and Mr. B both had classes that were single sex – female and male respectively. Upon investigating in the interviews, the reasons for this were based on two reasons. The first was that the majority of the Grade 10 ML year was predominantly female, but the second and far more prominent was to try and improve learner behavior in the classroom. Both Mrs. A and Mr. B believed that this did have a positive effect on the learners' behavior and focus in class. In addition, the single sex classes allowed the educators to make pedagogical links that were more specific and relevant to the group of learners. For example, Mr. B discussed how he could talk about male related interests more than in a mixed class and how this benefited his use of generating understanding in his learners.

This finding could prove a distinguishing element in the pedagogical styles of ML and Mathematics. While generating learner interest and motivation could be considered a global education consideration, the ML educators in this study seemed to emphasize that this was not just a consideration, but a key consideration in the pedagogical decisions making. Perhaps even more so than the development of the understanding of a concept so ingrained in Mathematics education.

4.6.5 Finding Five: ML Educators believe they are not effectively trained or educated in terms of ML pedagogy

The final major finding from this study was the resounding opinion that the educators were not effectively trained in ML pedagogy when starting teaching ML. All three educators were aware and had access to the ML CAPS document, however all referred to it as a minimum outline of content and topics for learning without offering much in way of pedagogical instruction. Mrs. A and Mr. B had been teaching other subjects for a number of years before being taking up ML teaching, and while Mr. B did mention the governmental workshop given to educators when ML was introduced into the curriculum, he was quick to say it was insufficient. Mrs. A mentioned she got nothing except being given the text book and instructed to teach. Ms. C being the

youngest and most recently in a university program did get some exposure during her tertiary education but clarified that it was incidental and not a planned aspect of her education.

While there have been ML educational courses introduced into tertiary level institutions, as discussed in Chapter Two, most of the ML educators are existing educators that have been moved into ML from other disciplines. This then raises the issue that if this is the case, the educators need to be given sufficient instruction into not only the content and format of the ML curriculum, but also the pedagogical practices that support it.

4.7 Reviewing the CAPS document

With the five main findings of the study being presented, we need to see how these findings relate to the current instructional documentation of ML. This is the national CAPS ML (2011a) document. The reason for this is to highlight any discrepancies or insights into how ML is intended to be taught and what the educators in this study are putting into practice.

To start off the CAPS document does not mention the word “pedagogy” once in the entire document. To be fair, this is expected as the CAPS document represents the latest curriculum and assessment policy for the national curriculum, however, from the information gathered from the educators, this is problematic as this is the primary document and sometimes the only source of information about ML the educators are exposed to. The document itself provides numerous goals, objectives and aims of the national curriculum as a whole and of ML as a subject, as well as detailed layout of the content over the three FET years.

In relation to finding one, the CAPS document does promote the process of linking and integrating concepts, even though it is not explicitly mention how to implement the links within the classroom. This is highlighted in the interplay diagram (Department of Basic Education, 2011a, p. 9) which represents the linking between mathematical concepts, competencies and skills, and real-life contexts. The diagram illustrates how ML tries to develop educational competency in learners through integration of concepts. This has been viewed in the pedagogical practices of the

participants whom displayed a variety of links in their pedagogical practices in the class room.

For finding two there is precious little in the CAPS document that indicates what type of conceptual linking should be used throughout a lesson. There is mention of the increased complexity of concepts from Grade 10 to Grade 11 to Grade 12, which may indicate to teachers how to approach the broader concepts, but again, nothing to indicate how and when to utilize linking within the class.

In fact there is not much at all that truly indicates how ML educators should make pedagogical decisions when teaching ML. There are a number of examples on questions with different scales of complexity and which content to focus on, but makes no mention or indication of how to link concepts and generate learner interest. This would seem to substantiate finding five, in that the educators feel that there has been little indication or instruction into how to teach ML, thus they fall back onto more comfortable or familiar pedagogical practices. It very much seems there is a disconnect or at least a feeling of disconnect between the current ML CAPS document and how educators teach ML.

4.8 Conclusion

This chapter has identified and discussed the patterns observed in the data of the pedagogical practices of the three participant educators with regards to the use of the 3 PLM approaches. It has discussed how these patterns had been observed and how the educators described their use of them. The thematic analysis of the data produced three main themes that spoke to the possible reasoning behind the educators' pedagogical decision making. From both of these analyses, the five main findings of the study were set out and discussed. Relating these findings to the ML CAPS document indicated a disconnect between the governmental information and teacher pedagogies. The next chapter will link these findings to the research questions in order to provide insight into the pedagogical practices of ML educators.

Chapter 5: Discussion of Findings and Conclusion

5.1 Introduction

This study looked to shed light on the current pedagogical practices of Grade 10 ML educators. This chapter will pull together the findings from the report and discuss them in relation to the initial research questions posed in Chapter One. It will discuss the limitations of the findings in terms of the scope and timing of the report as well as offer recommendations for future research pathways. It also houses a personal reflection on the study itself and the concepts it has revealed during its progression. Finally, this chapter will produce a final conclusion to the report in its entirety.

5.2 Relating Overall Findings to the Research Questions.

The scope of this study was focused by the two research questions. Here we will discuss how our findings speak to those questions and try to generate some answers.

The first question was:

What pedagogical practices are utilized by ML educators in the classroom?

The goal of this question was to open an investigation into the current trends or methods that ML educators use in the classroom. Our first finding speaks directly to this. All three educators demonstrated the use of a variety of different linking approaches. Not just the three PLM approaches from form one (support knowledge building), but from form two (promote continuity) and form three (encourage emotional engagement) as well (Scott et al., 2011). From finding two, they also demonstrated the use of the three specific approaches at different stages throughout the lesson. Thus we can conclude that the educators are able to implement a number of pedagogical practices that engage learners in the learning process.

However, it was the reasoning behind the pedagogical choices of the educators that provided some real depth to this question. Finding three highlights how the educators' perception of ML and the learners themselves affected their decisions in the classroom. This was apparent in the use of Approach one in the lessons as there was a significant use of everyday language throughout the lessons. This was reasoned to be so that the learners could understand the concepts more clearly; not to get confused with the scientific terms. While this seems logical, it does fly in direct

contradiction to the learning imperative given by Vygotsky (1978). Vygotsky (1978) discussed how engagement with a more complex, scientific concept, with the assistance of a teacher, would allow the learner to bridge the Zone of Proximal Development (ZPD) and develop understanding at a higher level. Through the increased use of everyday language that is derived – at least in part – by the educator's perception of ML and ML learners, the learners are denied critical and prolonged exposure to such scientific terms which promotes cognitive development. This point moves us onto the second research question:

In what ways do ML educators utilise links to negotiate the balance of everyday and scientific concepts within their pedagogical practices?

From the findings from this study it seems that the balance is towards the everyday more than the scientific. If we look at this in relation to finding four, there appears to be a supporting aspect. The educators displayed and discussed how generating learner interest and motivation was a key factor in their pedagogical decisions. Rather than focusing on conceptual development and understanding, generating learner engagement seemed a far stronger influencing factor on pedagogical decisions. They further discussed and demonstrated in the classroom that this seemed to require more everyday language. The educators seemed to believe use of everyday language aids this process of generating interest and allowed for better communication and relationship building in this regard. Thus the further use of everyday language in the classroom is promoted, further moving the tension between everyday and scientific concepts towards the former.

This tendency to move towards increased everyday language could be explained by our fifth finding in that the educators haven't been educated or educated effectively in any ML pedagogical practices. Their primary introduction and guidelines to ML is effectively the ML CAPS document, which has little, if any, instruction on how educators should teach ML. The educators were happy that they understood the content and the scientific concepts provided by the CAPS document, but the word *pedagogy* doesn't exist in the CAPS document, and so the educators are forced to learn ML pedagogy through personal experience. This supports the findings of Botha (2011) who mentioned this was a prominent problem in ML education. From a collective ML level, this would result in a very eclectic pedagogy that would be as

varied as the number of ML educators in South Africa. Obviously this is a major problem to developing a unified and distinct ML pedagogy that can be articulated and communicated to the ML educators.

5.3 Significance of Findings

While these findings cast an illuminating focus on ML educators, it also has ramifications for the ML learner, the ML subject and the National Curriculum as a whole.

At a participant level, the understanding of some of the tensions between learner engagement and relationship building, and concept development and learning would greatly affect the pedagogical practices of current ML educators. On one hand educators would need to focus more on learners engaging with crucial scientific terms and concepts, while on the other hand being more aware of the importance of relationship building in keeping the learner motivated and focused. All the while cognizant of keeping the balance through their pedagogical strategies. The focus on the increased use of scientific concepts in classrooms was actually highlighted as a key recommendation in the 2015 National Senior Certificate Examination Diagnostic Report (Department of Basic Education, 2015, p. 7), which emphasizes the validity of the finding. The additional complexity in South African classrooms is the high number of bilingual or multilingual students that have varying degrees of competency in the English language. So while striving to engage learners with more scientific terms is important, educators also need to recognize the additional difficulties of learners engaging in complex terms and concepts that fall outside of their lingual comfort zone, which would have a significant impact on the pedagogical practices and choices of the educator.

From a learners' perspective, understanding that ML is a distinct subject in its own right rather than being a lesser Mathematics, could lead to increased motivation, self-belief and a willingness to engage. Educators would be able to help ML move away from this negative perception through their own, and – through encouragement – those of the learners. This is greatly significant as 388 845 (59.57%) Grade 12 learners wrote ML in 2015, while only 263 903 (40.43%) learners wrote Mathematics (Department of Basic Education, 2015), meaning that the majority of Grade 12

learners in South Africa are not only dealing with learning mathematical content, but also having to deal with the negative perceptions of ML as a subject.

At an educational level, this study helps to add depth to the current understanding of ML within the South African curriculum. With ML still in its infancy as a school subject, any insight into potential issues and possible solutions can help the Department of Education improve on its already established teacher training programmes and documentation. Tertiary level studies can more accurately explore ML and impart a more distinctive perception and pedagogical practices onto budding educators. This would make a significant impact on the quality of future ML educators throughout a nation hungry for economic growth and population engagement in the economy.

At a theoretical level, these findings have taken a step further in vocalizing possible distinguishing pedagogical factors between ML and Mathematics. While concept development is an important aspect of any learning process, the impact of learner motivation on pedagogical choices needs to considered more predominantly than in Mathematics. Moreover, the perception problem of ML and ML learners seems to play an important role in ML pedagogy. While having a stigma attached to a specific subject is not unique, the *lesser* perspective needs to be altered if ML educators are to encourage learners to reach higher levels of cognitive functioning through engaging with more scientific terms and concepts.

Finally, there seems to be some evidence to support a pattern of education that educators follow through using PLM within the classroom. The use of Approach three during introductions as well as during more complex problems seems to indicate that the educators view this as an extremely important pedagogical tool in both knowledge construction and building relationships. Potentially, this could be yet another defining line between ML pedagogy and mathematical pedagogy, wherein the specific use of real world links can be pinpointed to certain topics or instances in a classroom.

All these would require further research, however, these findings have provided potential pathways for more in-depth studies of ML.

5.4 Recommendations for Future Research.

With the significance of the findings of this study in place, we can now discuss some of these potential pathways for future research.

The first one seems fairly straight forward, in that all three educators felt very strongly that they had not received any kind of effective training in teaching ML. The first recommendation would be to conduct research into how the South Africa Department of Education is educating ML teachers. Using the premises that a) the educators are learning to teach ML through their own experiences and b) that there needs to be greater understanding of the distinctions of ML pedagogy from other subjects, teacher educational programmes need to be updated.

The second reccommendation would be into the pattern of the PLM approach usage in the ML classrooms. If a broader pattern of approach usage across the districts, provinces or country can be identified, educators would have the makings of a pedagogical skeleton on which to anchor their pedagogical decisions, thus adding structure to a currently amorphous pedagogy. This could be the starting point for the development of a uniquely ML pedagogical strategy aimed at getting the best educational results out of ML educators and learners.

Moreover, this could be a defining point in the re-articulation of ML separated from Mathematics. As one of the three fundamental domains of education (Shepard, 2000), pedagogy both influences and reacts to both the curriculum and assessment. If the pedagogy of ML becomes more structured and clear, greater clarity on both relevant content and how to assess learners effectively becomes more defined. This would result in ML becoming more distinct as a subject of the national curriculum, which would in turn help alter the current *lesser* perspectives of ML. Should the overriding perspective of ML change, over time, both ML learners and educators would be affected positively.

A slightly lesser priority, but potentially interesting, avenue for research would be the impact on giving ML learners the choice of listening to music during lessons. This would not be on a group level, but as observed in some of the classes, on an individual level with the learners being able to choose their music during individual work sessions. The data from this study suggests that the educators used this as a

motivational activity as it made the learners focus more in class. If there was some definitive research into the educational validity of listening to music, or it could be proved that ML learners did focus more during work sessions, there are a number of new avenues to incorporate this into the uniquely ML pedagogy.

The final recommendation is to develop the PLM model to help guide ML pedagogical research. The PLM model was orginally designed for examining the pedagogical practices of Science education. This study focused and utilised a particular aspect of the model to provide initial insight, but with a full PLM study of ML pedagogies, far more in-depth analysis can take place. Over a protracted use, further general forms or approaches – or even ML specific forms or approaches – may arise leading to further breakthroughs. Pehaps looking at how ML educators enact form 3 (relationship building) as opposed to Science edcators would be a place to begin.

5.5 Limitations of this Study.

With every research study there are limitations. For this research report, there were a number of logistical limitations. Firstly the scope only encompassed three different educators. As a sample size of district, province or country this is a very small percentage, and while the qualitative nature of the study did allow for some in depth analysis and observations, the similar economic stature and geographical area of the Johannesburg north schools made for a comparatively narrow sample.

Within the methodology there were some limitations, particularly in the data collection. The use of video recording was not utilized due to the considerations of the anonymity of the participants, however having that visual and auditory record could have proved very insightful and added more weight to the evidence.

The concept of research bias (Norris, 1997) also played a part in this study. Primarily, the researchers previous experiences in teaching Grade 10 ML means that previous opinions and outlooks on ML education may have guided observations and questions during the interview. While there were significant attempts to overcome this limitation, they still remain. The researcher’s familiarity with the geographical area, economical demographics and previous work experience in the area may have shaped conclusions from observations and answers.

5.6 Personal Reflection.

I started this research due to my belief that ML was an extremely important subject to an educationally challenged country such as South Africa. From a social perspective, South Africa has a number of pressures on its development – none more so than in the educational sphere. For me, ML was a very good step in the right direction towards improving the earning potential and economic success potential of previously or currently disadvantaged or impoverished learners. It was from this social perspective that the rationale of trying to gain a deeper understanding of ML from an academic perspective arose.

Through the process of this report, I am pleased to say that my belief in the future and importance of ML in South Africa has been emboldend. From the observations and interviews it is clear that educators and learners alike seem to appreciate the subject, yet struggle to socially reconcile it with the traditional subjects of Mathematics, Science, and English. The participant learners seemed to really need the real world links in order to conceptualise scientific concepts and through the educators pedagogical practices and engagement with CAPS textbooks, the learners did appear to gain knowledge.

Not only was the societal aspect of ML strengthened, but my theoretical understanding of ML improved substantially. The finding that educators tended towards more everyday language resonated with me. I thought that the skill of an educator was in the ability to make links that learners can follow and understand, but now realise that this is not enough and that there needs to be a strong element of scientific concept exposure as well.

My insight into the different styles of teaching, yet similar uses of the approaches ignited my belief that there is a distinct pedagogy for ML and that with the right research, ML edcuators and learners could be aided greatly in reaching their academic and curricular goals. With this, the realisation of just how important continuous teacher education is to the education system was very apparent.

I personally feel that the findings in this report could pave the way for some serious development in ML education and tuition in the current CAPS curriculum, and with further research ML can really become a distinct subject, separated from Mathematics by not only goals and elements, but by insightful definition and different

pedagogical practices. Through this, ML educators and learners may be able to move past the negative stigma that surrounds ML today.

If we accept the premise that ML will be a long term aspect of the South African curriculum, and that the majority of high school student in South Africa take ML, then embracing a new, positive and distinct perspective of ML is of the utmost importance. Perhaps an initial step would be to re-brand ML as a subject, starting with a new name that does not ellicit a negative or lesser image of mathematics.

5.7 Conclusion.

This research report set out to explore the pedagogical practices of Grade 10 ML educators. A review of the current literature surrounding ML concluded that there were in fact problems with the perception of ML as a “dumbed down” version of Mathematics and that most ML educators in the country are moved in from other departments. This set the stage for the report to delve deeper into the pedagogical practices of such educators through the lens of PLM.

The three lessons for each educators were observed followed by a post-observation interviews which provided insight into the reasoning behind the observed pedagogical practices. The data was collected and analysed with five key findings being presented. This study has examined ML in order to add to the current understanding of the subject, and has provided a base from which potential avenues for further study in order to promote the development of ML pedagogy can be generated. This study highlights the need for ML to be distinct from Mathematics not only in content and assessment, but in the fundamental pedagogy utilised to best engage and educate the ML learners.

Reference List

Alexander, R. (2009). Towards a comparative pedagogy. In R. Cowen & M. Kazamias (Eds.), *International Handbook of Comparative Education* (pp. 923–942). Springer.

Bansilal, S. (2014). Exploring the notion of Mathematical Literacy teacher knowledge. *South African Journal of Higher Education*, *4*(28), 1156–1172.

Bernstein, B. (1999). Vertical and Horizontal Discourse: an essay. *British Journal of Sociology of Education*, *20*(2).

Botha, J. J. (2011). *Exploring Mathematical Literacy: The Relationship with teachers' knowledge and their beliefs and their instructional practices*. University of Pretoria, Pretoria.

Bowie, L., & Frith, V. (2006). Concerns about the South African Mathematical Literacy curriculum arising from experience of materials development. *Pythagoras*, (64), 29–36.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Braund, M., Ekron, C., & Moodley, T. (2013). Critical Episodes in Student Teachers' Science Lessons using Drama in Grades 6 and 7. *African Journal of Research in SMT Education*, *17*(1), 4–13.

Brown, B., & Schafer, M. (2006). Teacher education for mathematical literacy. *Pythagoras*, (64), 45–51.

Carrim, N. (1998). *The Development of Curriculum 2005*. Presented at the CIES World Congress, Cape Town.

Chisholm, L. (2005). The making of South Africa's National Curriculum Statement. *Journal of Curriculum Studies*, *37*(2), 193–208.

Christiansen, I. (2007). Mathematical Literacy as a school subject: Mathematical gaze or livelihood gaze? *African Journal of Research in SMT Education*, *1*(11), 91–105.

Creswell, J. (1994). *Research Design: Qualitative and Quantitative Approaches*. London: SAGE.

Creswell, J. (2003). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (2nd ed.). Sage Publications.

De Vos, A. (1998). *Research at grass roots: A primer for the caring professionals*. Pretoria: Van Schaik Publishers.

Department of Basic Education. (2011a). National Curriculum Statement: Curriculum and Assessment Policy Statement. Mathematical Literacy: Further Education and Training Phase. Department of Basic Education.

Department of Basic Education. (2011b). National Curriculum Statement: Curriculum and Assessment Policy Statement. Mathematics: Further Education and Training Phase. Department of Basic Education.

Department of Basic Education. (2015). *2015 National Senior Certificate Examination Diagnostic Report*.

Fleisch, B. (2007). *Primary Education in Crisis, Why South African school children underachieve in reading and mathematics*. Cape Town: Juta & Co.

Gernetzky, K. (2012). South Africa bottom of the class in maths and science. *Business Day Live*. Retrieved from http://www.bdlive.co.za/national/education/2012/10/31/south-africa-bottom-of-class-in-maths-and-science

Graven, M., & Venkat, H. (2007). Emerging pedagogical agendas in the teaching of Mathematical Literacy. *African Journal of Research in SMT Education*, *11*(2), 67–84.

Hoadley, U. (2011). Knowledge, Knowers and Knowing: Curriculum reforms in South Africa. In L. Yates & M. Grumet, *World Yearbook of Education 2011 - Curriculum in Today's World: Configuring knowledge, identities, work and politics.* (pp. 139–154). London: Routledge.

Hope, M. (2007). Mathematical Literacy. *Principal Leadership*, *5*(7), 28–31.

Jansen, J. (1998). Curriculum reform in South Africa: A Critical Analysis of Outcomes-Based Education. *Cambridge Journal of Education*, *28*(3), 321–331.

Julie, C. (2006). Teachers' preferred contexts for Mathematical Literacy as possible indicators for mathematics for action. *African Journal of Research in SMT Education*, *10*(2), 49–58.

Khoo, E., & Cowie, B. (2014). But the Learning Has Already Passed: rethinking the role of time in e-mediated learning settings. *E-Learning and Digital Media*, *11*(2).

Killen, R. (2003). Validity in outcomes-based assessment. *Perspectives in Education*, *21*(1).

Kilpatrick, J. (2001). Understanding mathematical literacy: The contributions of research. *Educational Studies in Mathematics*, *47*(1), 101–116.

Mashinyira, A. (2013). *Teacher mediation of link-making between what learners do and observe during practical activities (the domain of observables) and the concepts learnt in theory lessons (the domain of ideas.)* (Doctoral Dissertation).

Math Open Reference. (n.d.). Retrieved from http://www.mathopenref.com/

McMillan, J., & Schumacher, S. (2010). *Research in Education: Evidence-Based Inquiry* (7th ed.). Boston: MA: Pearson.

Merriam, S. (1998). Case Studies as Qualitative Research. In *Qualitative reasearch and case study applications in education*. San Francisco: Josey-Bass Inc.

Motshekga, A. (2013). Announcement of National Senior Certificate results for 2012. Retrieved from http://www.politicsweb.co.za/politicsweb/view/politicsweb/en/page71654?oid=348753&sn=Detail

Norris, N. (1997). Error, bias and validity in qualitative research. *Educational Action Research*, *5*(1), 172–176.

Olivier, W. (2013). *Reflection on the training of teachers for the CAPS mathematical curriculum - a brief report*. South African Mathematics Foundation. Retrieved from http://www.samf.ac.za/documents/CAPS_mathematics_curriculum.pdf

Piaget, J. (1964). Development and Learning. In R. Ripple & V. Rockcastle (Eds.), *Piaget Rediscovered*. Ithaca: Cornell university.

Scott, P., Mortimer, E., & Ametller, J. (2011). Pedagogical link-making: a fundamental aspect of teaching and learning scientific conceptual knowledge. *Studies in Science Education*, *47*(1), 3–36.

Shepard, L. (2000). The Role of Assessment in a Learning Cutlure. *Educational Researcher*, *29*(7), 4–14.

Sidiropolous, H. (2008). *The implementation of a madatory mathematics curriculum in South Africa: the case of mathematical literacy* (Philosophiae Doctor). University of Pretoria, Pretoria.

Terre Blanche, M., & Durrheim, K. (1999). Social constructionish methods. In *Research in practice: Applied methods for the social sciences* (pp. 147–177). Cape Town: UNiversity of Cape Town press.

Thalheimer, W. (2003). The learning benefits of questions. Retrieved February 23, 2016, from http://www.work-learning.com/ma/PP_WP003.asp

Trochim, W. (2006). Research methods knowledge base. Retrieved from http://www.socialresearchmethods.net/kb/dedind.php

Venkat, H. (2010). Exploring the nature and coherence of mathematical work in South African Mathematical Literacy classrooms. *Research in Mathematics Education*, *1*(1), 53–68.

Vygotsky, L. (1978). *Mind in Society*. Cambridge, MA: Harvard UP.

Yin, R. K. (2013). *Case Study Research: Design and Methods* (5th ed.). Thousand Oaks: Sage.

Appendix A

1. **Ethics Clearance Certificate from University of the Witwatersrand.**
2. **Ethics Clearance Certificate from Department of Education**
3. **Letter and Consent form – Principal of the school**
4. **Letter and Consent form – School Governing Body**
5. **Letter and Consent form – Participant teacher**
6. **Letter and Consent form – Participant Learner**
7. **Letter and Consent form – Participant Learners' Parents / Guardians**

Appendix B

1. **Interview Transcript**
2. **Observation Schedule**
3. **Observation Descriptions**
4. **Coding Tables**