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Analysing and understanding teacher development on a Mathematical Literacy ACE course

JE Hechter

Student number: 0419824A

Thesis for Master of Science

Supervisor: Prof Hamsa Venkatakrishnan

Declaration

I declare that this dissertation, except for aspects duly acknowledged, is my own unaided work. It is submitted for the degree of MSc at the University of the Witwatersrand, Johannesburg. It has not been submitted for any other degree at any other University.

……..

Janine Esther Hechter

…… day of …… 2011

Abstract

Mathematical literacy is a new subject area which developed largely because of the concerns with respect to the low numerical literacy levels of adults. In 2006, Mathematical Literacy was introduced as an optional school subject in South Africa in the Further Education and Training band (Grades 10-12).

This study focuses on Mathematical Literacy in-service training teacher development set in a large urban institution. The main aim of the study was to reflect on the development of meaning and understanding with respect to Mathematical Literacy curriculum interpretation and the Mathematical Literacy teaching practices of two teachers within an Advanced Certificate in Education (ACE) Mathematical Literacy course.

The data collected over time included ACE Mathematical Literacy course tasks and videotaped observations of the teaching of Mathematical Literacy of the selected teachers related to the use of a task based on data on gender-related smoking proportions across a range of countries. The study examined the relationship between context and mathematical content when Mathematical Literacy was discussed and when classroom practice was planned and presented. A spectrum of Mathematical Literacy teaching agendas, types and cognitive levels of questions used in classroom assessment tasks and ethical and moral class discussions were analysed.

The study revealed that the two teachers interpreted the Mathematical Literacy curriculum in different ways and their teaching practice resulted in a range of teaching practices with emphasis on either real-life contexts or mathematics. The study showed limited, but visible shifts in understanding with respect to meaning and practice. The key findings included the development of a range of questions for Mathematical Literacy assessment tasks, reference to the cognitive level of questions, including low-level reflective questions, the emergence of a moral value-based dimension in Mathematical Literacy teaching practice and an adaptation to the spectrum of Mathematical Literacy teaching agendas as developed by Graven and Venkat (2007).

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1 Introduction

In this study I focused on Mathematical Literacy teacher development within the empirical field of in-service training practice set in a large urban institution. I investigated the understanding and teaching practices of two teachers within an ACE (Advanced Certificate in Education) Mathematical Literacy course. The study examined the relationship between context and mathematical content when Mathematical Literacy was discussed and in episodes where classroom practice was planned and presented.

In the introductory chapter I provide a broad discussion on the notion of mathematical literacy as covered in literature on mathematics education, the notion of Mathematical Literacy[1] as a school subject in South African schools and the research problem for this study, followed by the research questions.

1.1 Background to mathematical literacy

Mathematical literacy, sometimes also referred to as numeracy, quantitative literacy, mathemacy or functional mathematics, is a newly developed subject area discussed in literature on mathematics education (Steen, 2001; Coben, 2004; Pugalee, 1999; Ellis, 2001; Skovsmose, 1992; DoE, 2003a; Venkatakrishnan and Graven, 2006; Graven and Venkat, 2007; Christiansen, 2006, 2009; Venkat, Graven, Lampen and Nalube, 2009; Vithal and Bishop, 2006). Research in this field primary developed because of concerns with respect to the numerical literacy levels of adults. Steen (2001, p1) claims that 'many educated adults remain functionally innumerate' despite years of schooling, and many college students need 'remedial mathematics', in particular with respect to statistics. Furthermore, in England the recent Skills for Life Survey (DfES, 2003) showed that 47% of adults had numeracy skill levels below Level 1- the level expected of an eleven year old pupil in a formal schooling program (Coben, 2004). The mathematical literacy levels of adults have been linked to the formal schooling that takes place in the classroom (Steen, 2001; Ellis, 2001). The concern is that learners are taught mathematics at school, but, for many learners, the mathematical knowledge does not become 'useful, flexible and adaptive' (Boaler, 1999).

Functional mathematics is taught in England at school level and in South Africa Mathematical Literacy is an emergent school subject since it was introduced in the education system in 2006. The school subject is presented as a different model in England and South Africa (Venkatakrishnan and Graven, 2006). In South Africa, in particular, the new subject still needs to find its place with respect to nature, purpose and teaching practice.

[1] Mathematical Literacy refers to the school subject in South Africa; mathematical literacy refers to the general notion of numeracy, quantitative literacy, mathemacy or functional mathematics.

Research on adult numeracy was neglected until recently and concepts and definitions of numeracy vary. Coben (2004) describes the research domain on adult numeracy as:

> A moorland, rather than a bounded field, because, like moorland, the edges are undefined and the land is uncultivated. (Coben, 2004, p3)

In South Africa an embedded Mathematical Literacy curriculum aim is that learners will be able to use the mathematical knowledge and concepts constructed in the classroom in real-life circumstances (DoE, 2003a). Steen argues that learners have to be taught how to make the link between mathematical content and real-life contexts. He describes the link when he states there is a need to see 'the world through mathematical eyes' (Steen, 2001, p1). These skills are needed to reason mathematically and make responsible decisions in the modern world. Ellis (2001, p2) argues that citizens and workers should 'have the ability to reason in a commonsense way in situations involving numbers, graphs and symbols'. Citizens should develop the notion of estimation (rules of thumb) versus abstract mathematical procedures. An example could be that citizens might calculate or estimate the sale price of an item if the percentage discount is given, or perhaps estimate how much to tip and then split a lunch bill. Another example might be choosing a cell phone contract that suits one's lifestyle. The choice might be between a contract that calculates call costs using per second and per minute billing. In this case the estimation of a call duration average is needed to make a sensible decision. The concern is that the lack of development of the skill to make classroom mathematics flexible and useful in a real-life context might result in citizens who could be described as numerically illiterate adults.

Some of the skills that have been identified as necessary for mathematically literate citizenship include: the understanding and the interpretation of statistics (Steen, 2001), estimation (Ellis, 2001, p2), multiple representations, mathematical reasoning and problem solving (Pugalee, 1999), the use of technology (Pugalee, 1999; Skovsmose, 1992) and reflective knowledge with respect to the use of mathematics in a critical social context (Skovsmose, 1992). To summarise, mathematical literacy refers to the ability to mathematically engage with real-life contexts in order to solve contextual problems and make responsible, competent choices.

1.2 Mathematical Literacy in South Africa

Mathematical Literacy is a new subject in the South African education system. Before January 2006, mathematics was offered as an optional subject in grade 10 to 12, that is the Further Education and Training (FET) phase. In January 2006 Mathematical Literacy was introduced as optional school subject in the FET phase. In January 2006 it became compulsory for learners to either take Mathematical Literacy or mathematics in this phase. Mathematical Literacy was introduced in grade 11 in 2007 and grade 12 learners wrote the first National Senior Certificate examination at the end of 2008.

Three reasons are noted in the literature (DoE, 2003a; Venkatakrishnan and Graven, 2006; Christiansen, 2006; Vithal and Bishop, 2006) as feeding in to the introduction of Mathematical Literacy as school subject in South Africa. The reasons are discussed below.

1.2.1 Political imperative and greater access to mathematics

Before 1994, during the time of the apartheid regime, the South African education system did not provide equal levels of education for members of all communities. The poor quality of education, or even lack of education in some communities, resulted in very low levels of verbal literacy and numeracy (DoE, 2003a, p9). The new political dispensation after 1994 led to the development of a revised policy for education in South Africa. The early policy documents of the reigning political party, the African National Congress (ANC), emphasized the need for transformation in Education in an effort to leave behind the legacy of apartheid. The ANC policy document (1994, p84) called for science and mathematics education to be:

> Transformed from a focus on abstract themes and principles to a focus on the concrete application of theory to practice. It must ensure that students and workers engage with technology through linking the teaching of science and mathematics to the life experiences of the individual and the community.
>
> (ANC policy document as taken up in Venkatakrishnan and Graven, 2006, p17)

The ANC highlighted the disciplines of Science, Mathematics and Technology as critical for achieving these goals. The ANC emphasized a shift in focus from abstract knowledge towards application of knowledge in practice. If this view is applied to mathematics, it means that the focus had shifted from abstract school mathematics towards the application of mathematics in real-life contexts. Mathematical Literacy also connects the components of mathematical contents to the solving of real-world problems (Department of Education (DoE), 2003a). Furthermore, according to the above quote, the aim was also to promote the use of technology, in other words calculators, computers, the internet, etc.

The inclusion of Mathematical Literacy gives many more learners access to mathematics since learners are compelled to take either Mathematical Literacy or mathematics in the FET phase since January 2006. Since the inclusion of Mathematical Literacy in South African schools in 2006, over 40% of National Senior Certificate candidates were exposed to a mathematical subject in the FET phase that would not have been the case previously (Venkatakrishnan and Graven, 2006, p15). According to Christiansen (2006, p10), in 2006, 200 000 more learners were given the opportunity to engage with mathematics than in previous years when mathematics was optional for all learners. Therefore, Christiansen (2006) claims Mathematical Literacy would ensure greater access to mathematics for all learners and might provide a more accessible opportunity for learners to pass a mathematical subject.

According to Christiansen (2006, p6) the implications of the National Curriculum Statement (NCS) for Mathematical Literacy (DoE, 2003a) can include the 'improvement of living conditions, social justice and democracy, in other words overcoming the apartheid legacy'. Christiansen argues that the inclusion of the subject might lead to transformation and upliftment of socio-political conditions of the South African society in order to overcome the historical barrier of apartheid. If learners use mathematics flexibly in real-life situations it will empower them to make responsible decisions which could lead to improved living conditions, for example when citizens use budgets to manage their personal finances or achieve entrepreneurial success.

1.2.2 The development of numerate citizens

According to the NCS for Mathematical Literacy (DoE, 2003a), the view of the Department of Education is that:

> The inclusion of Mathematical Literacy as a fundamental subject in the Further Education and Training curriculum will ensure that our citizens of the future are highly numerate consumers of mathematics. (DoE, 2003a, p9)

The Department of Education envisages that the inclusion of Mathematical Literacy will lead to learners becoming mathematically empowered adults who will be able to use mathematics in everyday life.

1.2.3 Poor performance in international mathematics tests

International studies such as the Third International Mathematics and Science Study (Howie, 1997, 2001, as taken up in Vithal and Bishop, 2006) indicated that South African learners perform very poorly in mathematics tests when compared to other countries (developing and developed countries). Since the end of 2008, with mathematics or Mathematical Literacy being compulsory for all learners up to grade 12, more learners are exposed to mathematics and therefore the expectation is that learners will have better results in future international mathematics tests.

1.3 The Mathematical Literacy curriculum and the role of the teacher

According to the NCS for Mathematical Literacy (DoE, 2003a), the definition of Mathematical Literacy is the following:

> Mathematical literacy provides learners with an awareness and understanding of the role that mathematics plays in the world. Mathematical literacy is a subject driven by life-related applications of mathematics. It enables learners to develop the ability and the confidence to think numerically and spatially in order to interpret and critically analyse everyday situations and solve problems. (DoE, 2003a, p9)

The Department of Education emphasizes that Mathematical Literacy calls for the application of mathematics in real-life contexts. The subject aims to make the learner more aware of and understand the role of mathematics in everyday contexts. It is evident from the above definition that

Mathematical Literacy involves both mathematical contents and contexts. According to the NCS for Mathematical Literacy (DoE, 2003a) and other guideline documents (DoE, 2008; DoE, 2005; DoE, 2006), these two components should be interconnected in the teaching and learning of the subject. The Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008) state:

> When teaching and assessing Mathematical Literacy, teachers should avoid teaching and assessing mathematical content in absence of context. At the same time teachers must also concentrate on identifying in and extracting from the context the underlying mathematics or 'çontent'. (DoE, 2008, p7)

The context and content might therefore be alternatively foregrounded in the Mathematical Literacy classroom.

Mathematical Literacy focuses on the use of basic mathematical skills (DoE, 2003a, p9) in solving real-life contextual problems. The contexts might include financial issues, map reading, timetables, estimation of areas and volumes, understanding of house plans and sewing patterns, reading statistical charts, and developing a critical stance with regard to mathematical arguments in the media (DoE, 2003a, p9-10). The focus is therefore on the development of life skills. According to the Department of Education the subject will lead to the development of:

> … a self-managing person, a contributing worker and a participating citizen in a developing democracy. (DoE, 2003a, p10)

In order to achieve these goals, learners (and teachers) need to understand both the mathematical content and the given context that allow for the use of basic mathematics knowledge to solve the contextual problem in integrated ways.

Mathematical Literacy aims to develop in learners the skill to use mathematics with confidence to understand, interpret and solve everyday problems. According to the NCS for Mathematical Literacy (DoE, 2003a) some learners might be anxious and distressed, or even suffer from mathsphobia (DoE, 2003a, p43) when mathematics is presented to them. Steen (2001, p3) also refers to 'mathematics anxiety' and 'mathematics panic'. My view going into this study was that if the mathematics is shared in a contextual environment which is already familiar to them, and even better, interests them, chances are that learners might respond in more open-minded ways and more positively with respect to the learning of mathematics. This view on the use of real-life contexts when teaching mathematics is shared by the Department of Education, for example where it states that Mathematical Literacy teachers should:

> … endeavour to win learners to mathematics. Real life contexts which lend themselves to mathematical ways of thought are ideal for doing this. (DoE, 2003a, p 43)

This view links to the opinion shared by Boaler (1999) who argues that (mathematical knowledge) transfer is more likely to take place if learners learn mathematics in a more integrated way through a problem-solving approach.

The NCS for Mathematical Literacy (DoE, 2003a, p9) defines Mathematical Literacy as 'life-related applications of mathematics', but on the other hand, the learning outcomes and assessment standards which describe the core of the subject have been described as 'distinctly mathematical' (Christiansen, 2006, p10). Hence, there appears to be an underlying tension between the aims within the Mathematical Literacy curriculum with respect to the emphasis on mathematical content and the real-life contexts. If the focus is too much on the mathematics in the Mathematical Literacy class, a learner might experience the encounter to be similar to a grade 8 or 9 mathematics class. It is important to note though, that, according to the rhetoric of the policy documents (DoE, 2003a; DoE, 2008; DoE, 2005; DoE, 2006); mathematical knowledge per se is not the goal of Mathematical Literacy in the way that it is in a grade 8 and 9 mathematics class. Christiansen (2006) argues that the Mathematical Literacy curriculum specification has a focus on mathematical concepts and skills and neglects the contextual focus. On the other hand there is evidence from Curriculum 2005 Mathematical literacy, mathematics and mathematical sciences (MLMMS) that if the focus fell too strongly on the context, the mathematical discussion might be neglected (Adler, Pournara and Graven, 2000). Consequently, learners might not learn to 'develop the ability and confidence to think numerically and spatially in order to …. solve problems' (DoE, 2003a, p 43). If the interconnected relationship between the context and the embedded mathematical knowledge is not identified and understood, learners might not develop to be mathematically empowered in the real-life context. If this is the situation the curriculum intentions might not be met since the teaching of the subject might not develop numerical confidence in learners to analyse, interpret and solve contextual problems. Christiansen (2006, p11) argues that these contradictions indicate that 'the curriculum is likely to contribute to the reproduction of social inequalities rather than promote social justice'.

The role of the Mathematical Literacy teacher is to teach learners to coherently make the link between the context and the mathematical content required for solving contextual problems. Graven and Venkat (2007) noted that Mathematical Literacy teaching could be approached in various ways with respect to the relationship between context and content. They developed a spectrum of teaching agendas to describe Mathematical Literacy teaching practices, based on empirical data. In short, Mathematical Literacy teacher practice could be described as stretching over a range of four teaching agendas ranging from a contextual to a mathematical frame. When the contextual frame is used the focus falls on the investigation of context and the mathematics is used in service of the context. The mathematical frame is situated on the other end of the spectrum of the teaching agendas. When the focus falls on the mathematics the context might be used as a vehicle to explain the mathematics. The classification specifies a range of agendas since the description of teachers' practice might move

between these two extreme end points when the emphasis shifts from the context to the mathematics, or vice versa. The spectrum of Mathematical Literacy teaching agendas is discussed in more detail in chapter 3.

1.4 The research problem

Mathematical Literacy, as noted above, is a new subject in the South African education system and is thus without the extended history of many other school subjects. Mathematical Literacy teachers need to develop an understanding of the nature and purpose of the subject and a notion of how to teach the subject. Teachers need guidance and training to enable them to teach Mathematical Literacy in order to make a coherent connection between the context and the mathematical content required for the solving of real-life contextual problems. This 'new pedagogy' is not easily defined and might range from the focus on context to mathematical content in one lesson or topic. The NCS for Mathematical Literacy (DoE, 2003a) advocates that teachers teach Mathematical Literacy in an integrated manner with respect to the notion of context and content. Learners will then acquire mathematical life skills which they could apply in real life. If this is achieved, mathematical content becomes useful, flexible knowledge (Boaler, 1999).

The 'newness' of the subject with reference to pedagogy and assessment has enabled a wide spectrum of curriculum interpretations with respect to the goals and teaching practice of Mathematical Literacy. Teachers appear to be unsure with respect to the interpretation of the Mathematical Literacy curriculum and how it might be taught and assessed (Graven and Venkat, 2007; Christiansen, 2006, 2009; Venkat et al., 2009; Vithal and Bishop, 2006). The confusion that prevails among South African teachers is sometimes evident when teachers refer to Mathematical Literacy as 'standard grade mathematics' or 'watered down mathematics', as noted in the Association for Mathematics Education of South Africa's submission on the subject statements for mathematics and Mathematical Literacy (AMESA, 2003). This confusion regarding the notion of Mathematical Literacy, referred to as quantitative literacy by Steen (2001), is also documented by Steen (2001, p5). The assessment of Mathematical Literacy, particularly with respect to the types and cognitive levels of the questions asked in assessment tasks, is also an area that is misinterpreted by teachers (Venkat et al., 2009).

Furthermore, textbook writers have different interpretations of the NCS for Mathematical Literacy (DoE, 2003a). Some text books are structured around different contextual settings where the embedded mathematics is extracted e.g. Mathematical Literacy for the Classroom Grade 12 (RADMASTE, 2007) and Mathematical Literacy for All, Grade 12 (Schools Development Unit (UCT), 2007); other text books are organized with respect to the Mathematical Literacy learning outcomes, in other words in relation to mathematical topics, and contexts are included to serve as a vehicle to do the mathematics, e.g. Study and Master Mathematical Literacy Grade 12 (Jakins and

Yeo, 2007) and Shuters Mathematical Literacy Grade 11 (Aungamuthu, De Waal, Houston, Krusekopf, Kunene, and Ntenza, 2006).

In summary: teachers receive mixed messages from policy documents, guidelines and text book writers as to what is expected from them in the Mathematical Literacy classroom. There is uncertainty as to how Mathematical Literacy should be taught and assessed in order to reach the outcomes intended by the NCS for Mathematical Literacy (DoE, 2003a). Hence teachers need to be guided to develop teaching practices and to set assessment tasks. The ACE in Mathematical Literacy was developed as one of the vehicles to train in-service teachers to teach Mathematical Literacy. In this study my focus is on two case studies of Mathematical Literacy teacher development within one module of an ACE Mathematical Literacy course set within a large urban institution.

1.5 The ACE in Mathematical Literacy

Given the newness of Mathematical Literacy and teachers' unfamiliarity with the school subject there was a great need for support and intervention to ensure that there were enough trained teachers to effectively teach the subject. The Department of Education conducted various teacher workshops in 2005 to train Mathematical Literacy teachers, but the need for further training and interventions persisted. In bridging the gap between curriculum demands and Mathematical Literacy teachers' knowledge, understanding and practice, a re-skilling course for practicing teachers was developed at an urban university. The ACE Mathematical Literacy course was designed as a pilot training programme focused on the 're-skilling' of in-service teachers from a range of subject areas to develop as Mathematical Literacy teachers. The ACE Mathematical Literacy teachers[2] that followed the program were mostly mathematics teachers, but some were educators teaching other learning areas such as science, accounting and technical subjects. The teachers that registered for the ACE Mathematical Literacy course needed to have a grade 12 qualification in mathematics.

The pilot programme for the ACE Mathematical Literacy ran from 2007-2008 and involved nineteen teachers from three township schools in Tembisa and Ivory Park in Gauteng. These areas might be described as 'previously disadvantaged' areas. Seven of the teachers taught Mathematical Literacy in their schools in 2007.

The ACE Mathematical Literacy course consisted of four modules. Two modules were presented across a full year and teachers attended the course twice a week for three-hour sessions, in other words one three-hour session per module per week. Module 1 (Introduction to Mathematical Literacy) and Module 2 (Number, Space, Shape and Measurement) were presented over 28 sessions each per module in 2007. Module 3 (Financial Mathematics and Functional Relationships) and Module 4 (Statistics and Probability) were presented in 2008 in the same manner. Module 1 gave Mathematical

[2]The term 'teacher' in ACE Mathematical Literacy teacher refers to an in-service teacher who was enrolled as a student on the ACE Mathematical Literacy course

Literacy teachers background knowledge with respect to the nature and purpose of the subject and how to teach it. Modules 2, 3 and 4 mainly focused on the mathematical content needed to teach Mathematical Literacy. Across all modules content was presented within real-life contexts. Overall therefore, the course was mathematically organized, but the content was always located and worked with in real-life contexts.

The course model incorporated university-based assessment of learning. School-based assessment of teaching practice was therefore not part of the formal course assessment. However, funding was provided within the ACE structure to incorporate school visits to see the seven ACE course students who were teaching Mathematical Literacy in their schools.

The ACE Mathematical Literacy programme aimed to enable teachers to critically analyse and interpret the Mathematical Literacy curriculum in order for them to develop an understanding of the curriculum and to discuss and develop a sound practice for the teaching of Mathematical Literacy. The formal course outcomes for the ACE Mathematical Literacy course were summarized in the official course outline as follows:

1. provide a course which covers issues relating to the NCS within an outcomes-based education (OBE) approach
2. offer the student teacher a range of teaching resources which he/she can critically evaluate and incorporate into his/her own teaching programme
3. develop an integrative approach to learning and teaching
4. promote an atmosphere which will foster active participation in the course
5. provide a space for dialogue with colleagues, and encourage this dialogue to be taken into the schools

1.6 The ACE in Mathematical Literacy and the research study

As indicated earlier, the course consisted of four modules. However, this research study was restricted to the empirical data collected during the presentation and assessment of Module 1, namely: The introduction to Mathematical Literacy. I was developer and presenter of Module 1 during 2007. Since the focus of the research study was on the sessions presented for Module1, I include the outcomes linked to this particular module:

1. Critical analysis of national and international literature on maths literacy
2. Introduction to the new FET curriculum documents
3. Discussion of the implementation of the Mathematical Literacy curriculum and the design of learning units for use in South African schools
4. Analysis of Mathematical Literacy learning materials and text books
5. Understanding the equivalence between the DoE FET Mathematical Literacy curriculum and SAQA Unit Standards

6. Analysis of exemplar matric Mathematical Literacy papers
7. Critical analysis of issues related to the contextualisation of mathematics

These outcomes aimed to improve the ACE teachers' knowledge and teaching competence with respect to Mathematical Literacy. The teacher's knowledge of the subject linked to his/her interpretation and understanding of national and international literature on mathematical literacy and the understanding of the Mathematical Literacy FET curriculum documents, namely the NCS for Mathematical Literacy (DoE, 2003a), the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008), the Learning Programme Guidelines for Mathematical Literacy (DoE, 2005) and the Teacher Guide for Mathematical Literacy (DoE, 2006). The module aimed to build teachers' understanding of the connection between the components of mathematical content and real-life context, and to emphasize this link within Mathematical Literacy teaching practice. The module focus was on the development of skills for planning, teaching and assessment, using a range of teaching and assessment strategies.

The Module 1 sessions involved a teaching practice that actively involved all the ACE Mathematical Literacy teachers throughout the sessions. The sessions could be described as interactive and student centred; teachers were asked to share their views and experiences and interact with me, the presenter, and each other.

The main aim of this research study was to reflect on the development of meaning and understanding with respect to Mathematical Literacy curriculum interpretation and Mathematical Literacy teaching practice of the ACE teachers, over the duration of Module 1. The data collected encompassed ACE Mathematical Literacy course tasks and videotaped observations of the teaching of Mathematical Literacy of selected teachers. The specific vehicle for focussing on teachers' developing understandings and practice over time linked to the use of a task based on data related to smoking patterns in different parts of the world. The ACE teachers were given statistics on these smoking patterns during the first session of the course. Early in the module they were asked to informally plan a lesson including questions they would ask using the data (Portfolio 1, 20 February 2007). Later, the ACE teachers were requested to use the same data and design a lesson and a worksheet for use in Mathematical Literacy teaching (Assignment 2, 11 September 2007). The seven ACE teachers who taught Mathematical Literacy in 2007 were asked to teach the lessons using the smokers' data (September, October 2007). These lessons were videotaped and the data were analysed for research purposes.

The critical questions of this research study link directly to the development of the understanding of the Mathematical Literacy curriculum as well as the teaching practice of the ACE Mathematical Literacy teachers that were participants in the course. Developing understanding and teaching practice were analysed with respect to shifts in the relationship between context and content.

1.7 Critical questions

The critical questions that I investigated for the research study are the following:

1.7.1 Question 1

How does the ACE Mathematical Literacy teacher understand the nature and purpose of Mathematical Literacy? How does this change over time?

In other words, how does the ACE Mathematical Literacy teacher understand and describe Mathematical Literacy in relation to the new Mathematical Literacy curriculum? Interview and module assessment data were to provide answers to this question. My focus was on the relationship between context and mathematical content when Mathematical Literacy was discussed or taught.

1.7.2 Question 2

How does the ACE Mathematical Literacy teacher teach Mathematical Literacy in the classroom? In particular:

- How does the teacher work with the relationship between mathematical content and context, and how does this change over time?
- What can be said about the types of questions and the cognitive levels of questions they develop for assessment tasks, and how does this change over time?

Question 1 may be linked to 'meaning' and question 2 to 'practice' in Wenger's social framework for learning (Wenger, 1998), so it became the overarching theoretical framework for the study. Meaning is inscribed in teachers' comments about Mathematical Literacy and in their preparation for teaching practice within the smoking context task (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007; Lesson presentation, September-October 2007).

In order to investigate these questions, I conducted a longitudinal case study on two ACE Mathematical Literacy teachers. The selection of these two teachers was made at a late stage of data collection and analysis. The process and reasons for this selection are described in chapter 4.

Trajectory data on the teachers' understanding of the nature and purpose of Mathematical Literacy and a snapshot of their teaching practice based on teaching with the specific data on smoking were observed as part of the ACE Mathematical Literacy course. The analysis of the data relating to the two teachers is discussed in chapter 5. The analysis indicated shifts in meaning and teaching practice over time. The following aspects emerged as themes in the study:

1. Teachers had different understandings of the Mathematical Literacy curriculum. They had different ideas on the teaching of the subject, as seen with respect to the relationship between mathematical content and context. The pedagogic spectrum of agendas

developed by Graven and Venkat (2007) was used as a framework to consider the educators' teaching practice.

2. Teachers included different types of questions at various cognitive levels in the assessment tasks they developed as part of the lesson planning and presentation for the ACE Mathematical Literacy course. The types of question include contextual and mathematical questions; however, the questions often did not link the context to the mathematics and vice versa. Furthermore, the cognitive level of questions set in assessment tasks was not always set at the range of cognitive levels intended by the Department of Education (DoE, 2008).
3. Ethical and moral value discussions emerged during the planning and presentation of the Mathematical Literacy lessons developed for the ACE Mathematical Literacy course.

1.8 Rationale for the research

1.8.1 Professional rationale as course presenter

I was co-writer, coordinator and presenter for the ACE Mathematical Literacy course. The professional rationale for the research was to understand teacher learning and participation on the ACE Mathematical Literacy course. The module strove for the development of knowledge of the meaning and purpose of the subject amongst teachers, as well as the development of teaching practices aligned with the aims of Mathematical Literacy. I intended to use my research findings to reflect on the course and the teaching practices used when presenting the course. If necessary, I aimed to offer suggestions on alternative or additional course outcomes and teaching strategies to enhance teacher learning in the course.

1.8.2 Mathematical Literacy teaching and learning in South Africa

My intention was to contribute to the improvement of the teaching and learning of Mathematical Literacy in South Africa. South African teachers need to develop a pedagogy specific to the teaching of Mathematical Literacy in the South African context that will enable optimal learning for Mathematical Literacy learners. According to the NCS for Mathematical Literacy (DoE, 2003a), the outcome of Mathematical Literacy learning is the development of competent citizens who are able to utilize mathematics, if necessary, to make real-life decisions. In this study, I investigated the Mathematical Literacy teaching of two ACE Mathematical Literacy course participants with respect to the elements of context and mathematical content, in particular with respect to the relationship between the two components. The focal teachers' development of assessment tasks, and the occurrence and nature of their ethical and moral values discussions in the Mathematical Literacy classroom were also analysed. My analysis led to insights and variations with respect to the Mathematical Literacy teaching practices as discussed in the spectrum of teaching agendas developed by Graven and Venkat (2007).

1.8.3 Mathematical education and research

This research contributes to the ongoing research in education on a national and international level with respect to the way in which Mathematical Literacy might be taught at school level to enhance adult numeracy worldwide. The study aims to contribute to understanding the nature of teacher learning with respect to the understanding and teaching of Mathematical Literacy and to contribute to the design of Mathematical Literacy teacher development.

In the next chapter I discuss Wenger's (1998) social theory of learning that was utilized as the theoretical framework for this research study. The rest of the research dissertation is structured as follows:

In chapter 3 the literature review is discussed and chapter 4 provides detail on the research design. In chapter 5 the stories of the two teachers are presented and analysed. In chapter 6 a cross-analysis across the two case studies is presented, followed by findings, recommendations and the way forward with respect to future research.

2 Theoretical framework

The first part of this chapter provides a brief summary of the social theory of learning as described by Wenger (1998). Wenger provides a theory of learning where learning is explored as part of a socially constructed world. Learning is seen 'in the context of our lived experience of participation in the world' (Wenger, 1998, p3). The teaching and learning of the ACE Mathematical Literacy teachers largely took place in the interactive setting of the ACE Mathematical Literacy classroom. The learning within an individual includes both individually constructed intellectual learning and learning as participation embedded within a community. This community for learning is defined by Wenger (1998) as a community of practice.

In the second part of the chapter I expand on the concept of community of practice and discuss the interconnected relationship between the learning components of meaning and practice (Wenger, 1998) with respect to the South African Mathematical Literacy curriculum and how teachers interpret, understand and teach the subject. Furthermore, I discuss the reasons why Wenger's learning theory is useful to use as a frame for the research study and how Mathematical Literacy understanding and teaching can be linked to the theory.

The empirical data for this study is largely collected within the community of learning of the ACE Mathematical Literacy course participants. The ACE Mathematical Literacy classroom is a community of practice that was developed for the purposes of teacher learning on the ACE Mathematical Literacy course.

2.1 Wenger's framework of learning

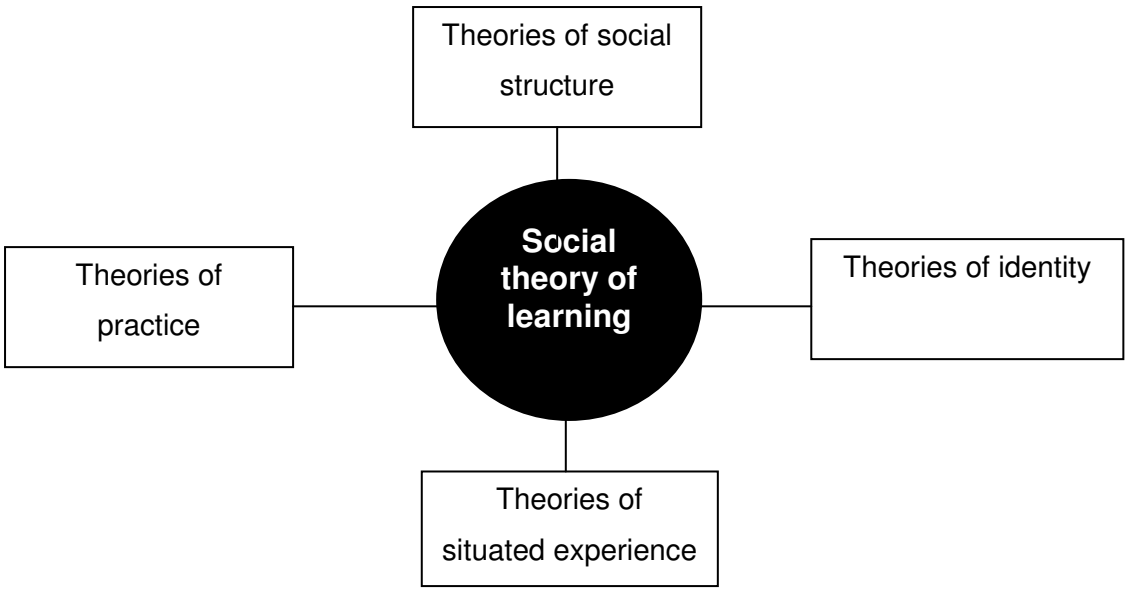


Figure 1 Wenger's Social theory of learning: Two main axes

Wenger explains the 'intellectual context' (Wenger, 1998, p11) of his social theory of learning by placing it at the intersection of two 'axes' of intellectual tradition (Figure 1).

The vertical axis is usually central and deals with the tensions between theories of social structure and theories of situated experience (Wenger, 1998, p12). Theories of social structure emphasise institutions, norms, cultural systems, discourses and history. These aspects explain social patterns and practices (Wenger, 1998, p12). On the other end of the vertical axis theories of situated experience emphasise experience and intentions. These factors address interactive relations between people and focus on individual or interpersonal events (Wenger, 1998, p13).

Wenger states 'learning as participation' is caught in the middle:

> It (learning) takes place through our engagement in actions and interactions, but it embeds this engagement in culture and history. Through these local actions and interactions, learning reproduces and transforms the social structure in which it takes place. (Wenger, 1998, p13)

Two main communities of practice are involved in this study, namely the ACE Mathematical Literacy classroom and the ACE Mathematical Literacy teacher's school classroom. The ACE Mathematical Literacy course aimed for alignment between the two communities of practice. However, it might be noted that these two communities of practice were different, for instance in the artifacts used, since the ACE Mathematical Literacy course, for example, included academic reading.

One of the implications of the 'newness' of Mathematical Literacy is that it has fewer established norms due to lack of history with respect to the teaching of the subject. Structure for the ACE Mathematical Literacy classroom and the ACE Mathematical Literacy teachers' school classrooms is drawn from the advocacy of the broad definition of teaching of the Department of Education (DoE, 2003a) and the NCS for Mathematical Literacy (DoE, 2003a) and guideline documents (DoE, 2008; DoE, 2005; DoE, 2006). The structure used for the ACE Mathematical Literacy classroom was aimed to align with the intention of the Department of Education in order to model the ACE teachers' Mathematical Literacy classrooms. The structure in the ACE Mathematical Literacy classroom and the Mathematical Literacy teachers' classrooms refer to the nature of teaching and learning advocated by the Department of Education, namely outcomes-based education that is set out to develop critical thinking within the minds of learners at a broad level, with the specific focus on the Mathematical Literacy curriculum. The structural emphasis was on the critical and developmental outcomes as described by the Department of Education (DoE, 2003a, p10), and the learning outcomes and assessment standards for Mathematical Literacy (DoE, 2003a, p14) and guidelines how to teach the subject. However, as noted in chapter 1, there are mixed messages given by the NCS for Mathematical Literacy and guideline documents (DoE, 2003a; DoE, 2008; DoE, 2005; DoE, 2006) which appear to accommodate different views. These tensions are discussed in greater detail in chapter 3.

On the other end of the axis the theories of situated experience refer to the actual practical experience of teaching and learning of teachers in the Mathematical Literacy classroom. The focus is on subjective ways of thinking about Mathematical Literacy, in other words the meaning of Mathematical Literacy, as well as teaching practice including lesson planning, presentation and assessment.

Wenger's work is mostly focused on the horizontal axis. However, the horizontal axis is 'set against the backdrop of the vertical one' (Wenger, 1998, p13). On the one end of the horizontal axis, theories of social practice focus on the production and reproduction of ways of engaging with the world while emphasizing social systems of shared resources (Wenger, 1998, p13). On the other end of the horizontal axis are theories of identity. Wenger explains that on this horizontal axis learning is again caught in the middle:

> It (learning) is the vehicle for the evolution of practices and the inclusion of newcomers while also (and through the same process) the vehicle for the development and transformation of identities. (Wenger, 1998, p13)

The ACE Mathematical Literacy teachers largely drew on the shared resources offered by the ACE Mathematical Literacy course. The material included literature on mathematical literacy and the South African Mathematical Literacy curriculum documents (DoE, 2003a; DoE, 2008; DoE, 2005; DoE, 2006). These resources were used by the ACE teachers to develop meaning and ways of teaching Mathematical Literacy.

On the other end, theories of identity focus on the social development of the person, the creation of community membership and the development of social categories (Wenger, 1998, p13). This membership was with respect to the new Mathematical Literacy curriculum and ways of teaching the curriculum and linked to participation in the ACE Mathematical Literacy teacher group.

In the ACE Mathematical Literacy classroom, social practice developed in a classroom described by interactive teaching and learning. My role as presenter of the course was to act as facilitator of the process of learning. Ideas on the meaning of Mathematical Literacy with respect to the curriculum and the Mathematical Literacy teaching practice were shared, discussed, commented on and evaluated in relation to curriculum expectations by me, the presenter of the course, and the members of the class (the ACE Mathematical Literacy teachers). The classroom practice followed in the ACE Mathematical Literacy classroom included group work, pair work and individual assignments. Group work refers to collaboration between the members of a team and included group discussions and feed-back, visual presentations and lesson plan posters by the group. The ACE Mathematical Literacy teachers came from different backgrounds and specialized in different learning areas - namely mathematics, science, accounting and technical subjects. They had different teaching experiences and viewpoints on Mathematical Literacy and how it should be taught. The majority of the ACE teachers

were newcomers to the field of Mathematical Literacy. This meant that the ACE Mathematical Literacy course was, in the initial stages at least, a key community of practice within which understandings of Mathematical Literacy and possible ways of teaching the subject were gained.

The teaching practices used for teaching Mathematical Literacy in the ACE course could also be seen as shared resources since views on Mathematical Literacy and the teaching of the subject were shared amongst the ACE Mathematical Literacy presenter and teachers.

2.2 Communities of practice

Lave and Wenger (1991), as taken up in Wenger (1998), claim learning is embedded in the process of co-participation within a community and can be described as an interactive process where the members perform various roles. Lave and Wenger state '(learning) implies becoming a full participant, a member, a kind of person…' (Wenger, 1998, p53). Wenger (1998) describes communities of practice for learning as informal communities of learning that are found all around us. He distinguishes communities of practice from other communities and points out that a residential neighbourhood, often referred to as a community, is not a community of practice for learning. He associates community and practice together in a way that defines a special type of community. He states that the term community of practice should be viewed as a unit. Wenger writes:

> On the one hand, a community of practice is a living context that can give newcomers access to competence and also can invite a personal experience of engagement by which to incorporate that competence into an identity of participation. On the other hand, a well functioning community of practice is a good context to explore radically new insights without becoming fools or stuck in some dead end. A history of mutual engagement around a joint enterprise is an ideal context for this kind of leading-edge learning, which requires a strong bond of communal competence along with a deep respect for particularity of experience. When these conditions are in place, communities of practice are a privileged locus for the creation of knowledge. (Wenger, 1998, p214)

Given that almost all the ACE Mathematical Literacy course teachers began the course with no prior experience of teaching Mathematical Literacy, the community of practice constituted by the ACE Mathematical Literacy classroom formed the key community of practice in relation to the teachers' learning and development. Furthermore, as noted previously, the ACE Mathematical Literacy teacher's own school classroom is also an important community of practice where teacher learning took place. However, only seven teachers who enrolled for the ACE Mathematical Literacy course had the opportunity to teach Mathematical Literacy during 2007.

Wenger (1998) views the community of practice as a unit of analysis. In this research study, the above mentioned communities of practice were not the units of analysis, but they were the site for my reflection and formed the central resource for the study of teacher development.

Apart from the above mentioned communities of practice, each Mathematical Literacy teacher fitted in or connected with various other communities of practice. These communities of practice

overlapped and influenced each other and created a range of possible communities for learning and development. I note here the probable existence of the following connected communities of practice:

1. The Mathematical Literacy teacher as part of his or her school staff, hence teachers from all learning areas
2. The Mathematical Literacy teacher as part of the Mathematical Literacy department at his/her school
3. The Mathematical Literacy teacher as part of the school 'cluster'. The concept 'cluster' refers to the regular meetings teachers from the same learning area, but from different schools have on regular intervals.
4. The Mathematical Literacy teacher as a learner at workshops presented by the Department of Education. These workshops are focused on content knowledge with respect to Mathematical Literacy or on classroom practice as described by the NCS.

2.3 Wenger's four components of learning

Wenger's framework for learning is often described as a social theory of learning. Wenger emphasises that learning is inevitable since failing to learn something involves learning something else (Wenger, 1998, p4). The two axes that describe Wenger's learning theory (

Figure 2) link to the four components of learning, namely: meaning, practice, community and identity. Theories of social structure link to learning when belonging to a community; theories of situated experience on the other end of the vertical axis, link to individual meaning acquired as a result of learning. Theories of practice refers to learning as doing; on the other end of the axis theories of identity link to learning as becoming, therefore developing an identity within a community of practice. Wenger notes that the elements of learning are 'deeply interconnected and mutually defining' (1998, p5). These components of learning are defined (Wenger, 1998) as follows:

1. Meaning is a way of talking about our ability to experience the world as meaningful;
2. Practice is a way of talking about shared historical and social resources, frameworks and perspectives that sustain mutual engagement in action;
3. Community is a way of talking about the social configurations in which our enterprise is defined and our participation is recognisable as competence;
4. Identity is a way of talking about how learning changes who we are.

Wenger summarises this social framework for learning in

Figure 2. He states:

> You could switch any of the four peripheral components with learning, place it in the center as the primary focus, and the figure will still make sense. (Wenger, 1998, p5)

It can therefore be noted that the elements of meaning, practice, community and identity are interconnected and influence each other.

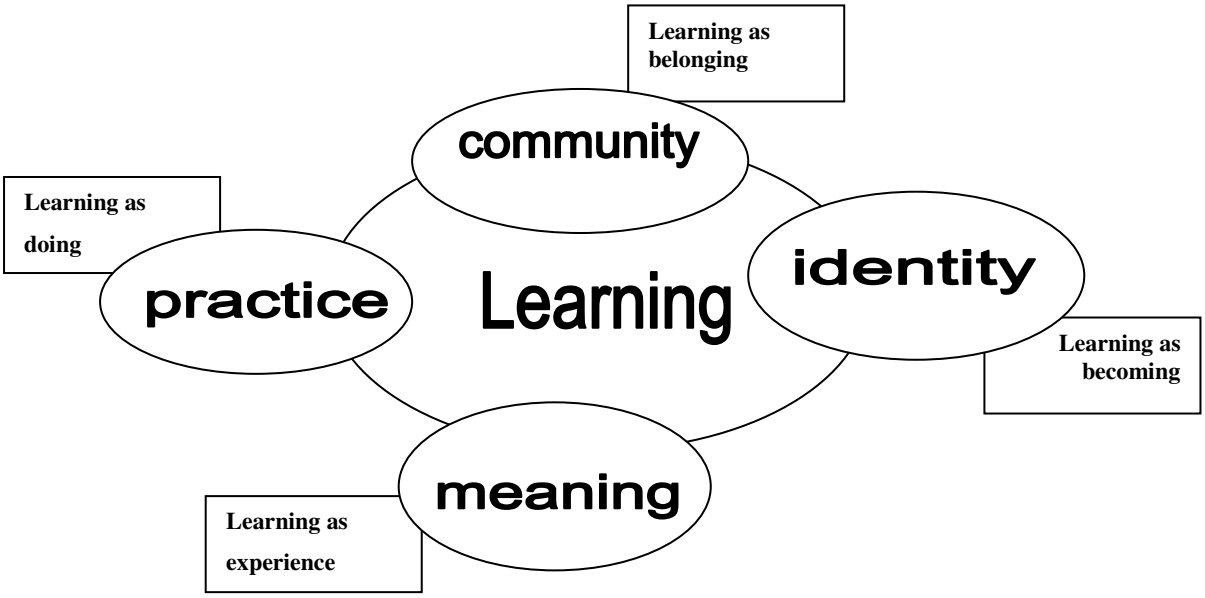


Figure 2 Wenger's components of learning

Why is Wenger's theory of learning (1998) used as theoretical framework?

Wenger's social theory of learning is a useful framework with respect to the aims of the ACE Mathematical Literacy course and the research questions for this study. The course and research questions focus on Mathematical Literacy teacher development with respect to the understanding and teaching of the subject. Given the 'newness' of Mathematical Literacy, the teachers on the course were largely inexperienced with respect to the new Mathematical Literacy curriculum and how it might be taught. The course aimed to support the development of the teachers' understanding of the nature and purpose of the Mathematical Literacy curriculum and experience it as meaningful, and to have them develop Mathematical Literacy teaching practices aligned with these developing understanding. Therefore, for the purposes of the research study I focus on Wenger's learning components of meaning and practice.

According to Wenger's theory of learning (1998) the components of meaning and practice are interconnected; they influence each other in the process of learning. The empirical data that was collected as part of this research study showed nuanced interpretations connected to meaning and practice. These interpretations are discussed at length in chapter 5, the analysis chapter.

Whilst the Wenger's theory of learning (1998) would suggest that the components of community and identity are present in the empirical data and analysis, they fall outside the scope of the analysis of this study.

Wenger's theory is successfully utilized in other mathematical educational research studies focused on teacher development, in particular the research done by Graven (2002, 2003, 2004, and 2005). Graven investigated all four of Wenger's learning components in her study of mathematics teacher learning in relation to a two year In-Service Education and Training (INSET) programme stimulated by curriculum change.

In the next sections I further unpack the components of meaning and practice.

2.3.1 Meaning

Understanding the development of ACE Mathematical Literacy teachers' notions of Mathematical Literacy and its teaching forms a key part of this study. Wenger describes meaning as our ability to experience the world as meaningful. Meaning is understood as an experience in relation to practice since meaning connects to a way of doing or practice. This process of creating meaning is an active process and is both dynamic and historical. New meaning links to historical meaning that has taken place and has been reflected on.

Within the ACE Mathematical Literacy course, a course aim was that the teacher would, over time, develop his/her own notions of the subject of Mathematical Literacy and how to teach it. The development was expected to largely take place within the community of practice of the ACE Mathematical Literacy classroom. In the context of the research the learning component of meaning was sought in terms of the ACE teachers' understanding and experience of the new Mathematical Literacy curriculum as meaningful, as well as talk about ways of teaching the curriculum. Emerging within the meaning category was reference to ownership of what it meant to be mathematically literate, in other words to understand and voice the nature and purpose of the subject in the teachers' own words. I also focused on tracing the ACE teachers' changing understandings over time as the ACE course and communities of practice evolved. This study aimed to track changes in understanding as a key indication of learning within the research design.

2.3.2 Practice

The development of Mathematical Literacy teaching practice was a course aim of the ACE Mathematical Literacy course. Wenger (1998) describes practice as a shared history of learning and notes that practice is neither stable, nor an object, but rather an emergent structure. The nature of practice is that it changes and develops over time.

In this study, data on the practices component was collected through a focus on lesson planning and snapshots of Mathematical Literacy lesson presentation involving the smoking data. The understanding and experience of the Mathematical Literacy curriculum and its outcomes as meaningful by the teacher will, according to Wenger's theory (1998), lead to the establishment of a classroom practice, or change an existing practice, and vice versa. In other words the learning component of meaning connects to the learning component of teaching practice in this study.

Reflection on the outcome of the teaching practice will, in turn, influence the teachers' understanding and interpretation of the Mathematical Literacy curriculum, and change in meaning and practice will again occur. This dynamic, on-going process could be described as learning in Wenger's terms (1998). The empirical data for this study indicated that the ACE Mathematical Literacy teachers' meanings and practices were not straightforwardly linked, an issue that is discussed in further detail in the analysis chapter.

In the next chapter I discuss international and national literature on mathematical literacy and the teaching of Mathematical Literacy, with focus on the South African context. The literature review is used to frame the analysis and interpretation of the empirical data. This is done against the theoretical background of Wenger's social theory of learning (1998).

3 Literature review

This chapter is divided in two sections. The first section focuses on the nature and purpose of mathematical literacy, including why the notion of mathematical literacy was introduced. The second section is a discussion of Mathematical Literacy in the South African context and focuses on the South African curriculum interpretation of the nature of the subject and policy in relation to Mathematical Literacy teaching practice. To conclude, the literature discussion is linked back to the theoretical framework used for this research study, namely Wenger's social theory of learning (1998).

3.1 The nature and purpose of mathematical literacy

3.1.1 Why mathematical literacy?

3.1.1.1 Evidence of innumeracy

The need for mathematical literacy developed out of concerns with respect to the numerical literacy levels of adults (Steen, 2001; Coben; 2004). Many learners, and as a result also adults, struggle to apply the mathematics they learn within the school curriculum in a flexible (Boaler, 1997) and useful way in real-life situations. Many citizens can be described as numerically illiterate (Steen, 2001; Coben, 2004). Examples given in the literature as to what numerical literacy entails include reconciling a bank statement, splitting a lunch bill or deciding which cell phone contract best fits their budgets (RADMASTE, 2007).

3.1.1.2 The need for adults to be more numerate when making real-life decisions

Steen (2001, p1) claims that 'many educated adults remain functionally innumerate'. He argues that citizens need to know more than formulas and equations, that they need to see the world through mathematical lenses, and to 'see the benefits of thinking mathematically about commonplace issues' (Steen, 2001, p2). Ellis (2001) also argues that 'the nation requires that citizens and workers have the ability to reason in a commonsense way in situations involving numbers, graphs, and symbols.' Citizens need to be mathematically equipped in order to approach real-life problems with confidence.

Steen (2001), Pugalee (1999) and Ellis (2001) argue that citizens need access to mathematics and the ability to apply it to real-life situations. Pugalee (1999) describes the aim of mathematical literacy in terms of obtaining full access to the school curriculum and to participate fully in the adult world. The utilitarian argument states that mathematical literacy will enable learners (and adults) to use the school mathematics that they have learned effectively to make personal decisions in real-life contexts. Steen claims mathematical literacy 'empowers people by giving them tools to think for themselves, to ask intelligent questions of experts, and to confront authority confidently' (2001, p2). In other words, it would empower an individual to be more knowledgeable, have the confidence to ask questions and then make well-informed decisions. Ellis claims that 'the education community needs to find an appropriate balance between teaching rules of thumb that can get the job done quickly and intellectual

abstractions' (2001, p62). In addition Steen refers to 'confidence in estimation' (2001, p8). Communities need members who can estimate answers and give ballpark figures in order to make decisions, without the lengthy calculations that go hand in hand with the abstract nature of mathematics.

In summary, mathematical literacy is viewed as a citizen skill or competence in literature on mathematical literacy. As noted in chapter 1, Steen (2001) states that learners have to be taught how to make the connection between mathematical content and real-life contexts in order to reason mathematically and make responsible decisions in the modern world.

3.1.2 What is mathematical literacy?

Mathematical literacy is largely described in two ways in international and local literature in relation to the nature of the link between content and context. The frame for description could be described as either a contextual or a mathematical frame. It is useful to describe the two frames since empirical evidence in South Africa has led to theories that teachers may choose to work in either of the two frames at different stages of their teaching practice. When a teacher works in a contextual frame the emphasis falls on the context and the mathematics is backgrounded. On the other hand, if a teacher foregrounds the mathematics, the context will be used as a vehicle to do the mathematics. In the next section I discuss mathematical literacy as seen from the viewpoint of the two frames; the contextual and the mathematical frame.

3.1.2.1 Contextual frame

I describe two contextual frames for mathematical literacy - the one is developed by Steen (2001) and the other by Skovsmose (1992).

Steen describes quantitative literacy from a contextual perspective as a 'habit of mind, an approach to problems' (Steen, 2001, p5). He states further that 'numeracy is often anchored in data derived from and attached to the empirical world'; it is not the same as pure mathematics, neither is it watered down mathematics (Steen, 2001, p5). Steen's emphasis is largely on the context when he states:

> Numeracy has no special content of its own, but inherits its content from its context.
> (Steen, 2001, p17)

Steen (2001) further describes quantitative literacy as follows:

> Quantitative literacy involves mathematics acting in the world. Typical numeracy challenges involve real data and uncertain procedures but require primarily elementary mathematics. The test of numeracy, as of any literacy, is whether a person naturally uses appropriate skills in many different contexts. (Steen, 2001, p6)

The above quote indicates a specific nature of the relationship between mathematics and mathematical literacy with the mathematics used, selected and embedded in the context. Steen distinguishes distinctly between school mathematics and quantitative literacy. He claims that the disconnection

from meaningful contexts when doing mathematics often results in an absence of common number sense, which makes mathematics hard to use meaningfully in different contexts, e.g. history, geography, economics, biology, agriculture, arts, and so forth (Steen, 2001, p3). Pure mathematics grows in complexity when the mathematical structures and concepts build onto each other; therefore it grows more abstract and complex.

Steen (2001, p5) claims quantitative literacy should be presented within an authentic context. According to Steen 'numeracy in real contexts that are meaningful… will develop the habits of mind of a numerate citizen' (2001, p18). Authentic, meaningful contexts have to be understood and mathematics has to be selected and applied to understand and solve contextual problems and make informed decisions.

Steen notes the following elements of quantitative literacy (Steen, 2001, p8):

1. Confidence in maths as opposed to 'maths anxiety'
2. Cultural appreciation and the understanding of the nature and history of mathematics
3. The ability to interpret data
4. Logical thinking, which includes analyzing, reasoning, questioning and evaluating data and solutions
5. Making decisions, which include the use of mathematics to make informed decisions and solve problems in everyday life.
6. Mathematics in context, where mathematical tools are used in situations where the context is meaningful.
7. Number sense, which includes estimation and common sense when working with numbers
8. Practical skills, the skill to know how to solve quantitative problems that one may encounter at home or at work.
9. Prerequisite knowledge, which involves the ability to draw on previously acquired knowledge and to use it flexibly in different contexts.
10. Symbol sense, which refers to the use of algebraic symbols when solving problems

Points 5, 6, 8 and 9 clearly reflect the view that mathematical literacy should be anchored in real life. The element on cultural appreciation and the nature and history of mathematics (point 2) and the ability to interpret data (point 3) also suggest world-related links, whilst some of the other points contain facets of the skills and dispositions needed to make the link between mathematics and contexts.

According to Skovsmose (1992), mathematical literacy (or mathemacy), is the quantitative knowledge that a school graduate needs to be a functioning, contributing and critical member of the modern society. Skovsmose (1992, p7) states that being a critical citizen involves the investigation of

conditions for obtaining knowledge, identifying and evaluating social problems and reacting to social problems (1992, p13). Skovsmose follows a critical political line in relation to mathematical literacy since he aims for a fairer society for all citizens. He argues that mathemacy involves mathematical knowledge (skills), technological knowledge and reflective knowledge where a person needs to organize, reorganize, reflect and evaluate whether (a) solution(s) to a problem is possible and responsible. Technological insight is described as necessary to support or reject reflections. He states 'while technology aims at solving such problems, the objective of reflective knowledge is an evaluation of a suggested technological solution to some problems' (1992, p13). The learner investigates different solutions to a specific problem and then chooses the most appropriate solution. The ability to evaluate critically provides the person with a competence that empowers the person, and therefore also the community and society.

To conclude, Steen (2001) claims that citizens can solve authentic, real-life problems with the aid of elementary, simple mathematics, following uncertain procedures. The ability to solve these real-life problems would enable citizens to make competent, responsible decisions in order to function in the world. Skovsmose (1992), on the other hand, follows a more reflective, critical line when he suggests the use of mathematics and technology to solve problems set in real-life contexts. His aim is the development of critical citizens who can reflect on the mathematical solutions of real-world problems in order to develop equal societies where justice prevails.

3.1.2.2 **Mathematical frame**

The mathematical frame for Pugalee's (1999) version of mathematical literacy sharply contrasts with the views of Steen (2001) and Skovsmose (1992) since the emphasis falls largely on the mathematics. The use of authentic contexts (Steen, 2001, p5) is less important since the context mainly acts as a vehicle to explain the mathematics.

Pugalee (1999) introduces a model for mathematical literacy embedded in a largely mathematical frame. He distinguishes between four processes that occur when 'doing mathematics' (1999, p20). The processes are representing, manipulating, reasoning and problem-solving. Representations involve the skill of moving between multiple representations or mathematical models for a mathematical concept, e.g. between equations, graphs and tables. Manipulating refers to the 'performing of calculations using algorithms and procedures successfully' (1999, p20), which includes the use of calculators and other technology. Reasoning mathematically includes making conjectures, gathering evidence, building an argument and justifying the answer. Problem-solving involves 'the use of prior knowledge and skills in moving towards a resolution that lacks an apparent resolution' (1999, p20). Pugalee claims that 'mathematical literacy is a complex interaction of these processes' (1999, p20).

Pugalee further explains that these processes are linked to three enablers that 'facilitate the doing of mathematics' (1999, p20). The enablers are communication, technology and values. Communication can be verbal and/or written. Technology refers to the use of technological tools, e.g. calculators and computers. Pugalee states that research has pointed out that 'the use of calculators encourages the development of higher-order thinking during mathematical problem solving' (Nohda, 1996 as taken up in Pugalee, 1999, p20). It is important for learners (and teachers) of mathematical literacy to be technologically competent. Values, according to Pugalee, refer to 'emotions, beliefs and attitudes toward doing mathematics and the nature of mathematics itself' (1999, p21). This view with respect to values emphasizes the largely mathematical frame.

3.2 Mathematical Literacy in South Africa

According to the South African curriculum document, Mathematical Literacy is 'a subject driven by life-related applications of mathematics' (DoE, 2003a, p9). The curriculum appears to be a hybrid of the contextual and mathematical orientations presented in the previous section (Steen, 2001; Skovsmose, 1992; Pugalee 1999). According to the introductory discussion the purpose of the subject is to create a community of responsible citizens, contributing workers and self-managing persons (DoE, 2003a, p43). Numeracy skills are viewed as necessary to make responsible and practical decisions in the modern world (DoE, 2003a).

Mathematical Literacy is a learning area where context and mathematics are intended to be interrelated in order to solve real-life problems. Mathematical Literacy integrates mathematical calculations with the need to solve problems in a range of everyday situations; therefore, the idea of mathematical content linked with everyday contexts is central to the notion of Mathematical Literacy as described in the South African Mathematical Literacy curriculum (DoE, 2003a; DoE, 2008; DoE, 2005; DoE, 2006).

The curriculum for Mathematical Literacy in South Africa is presented in the National Curriculum Statement (NCS) Mathematical Literacy (DoE, 2003a). The policy document provides the full curriculum statement, beginning with rhetoric on the nature and the purpose of the subject and proceeding to the four learning outcomes and relevant assessment standards for grades 10 to 12, in other words the post-compulsory FET band. This curriculum statement gives direction on what to teach and the purpose of Mathematical Literacy. The South African curriculum underlines a teaching approach anchored in context when it states:

> Teachers engage with context rather than applying mathematics already learned to the context. (DoE, 2003a, p42)

There are three further guideline documents (DoE, 2008; DoE, 2005; DoE, 2006) that provide detail and support on how to teach and assess Mathematical Literacy. The guideline documents are:

1. The Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008)
2. The Learning Programme Guidelines for Mathematical Literacy (DoE, 2005)
3. Teacher Guide for Mathematical Literacy (DoE, 2006)

The Subject Assessment Guidelines (DoE, 2008) appears to follow an integrated approach where the focus is both on the context and the mathematical content when it states:

> On the one hand, mathematical content is needed to make sense of real life contexts; on the other hand, contexts determine the content that is needed. (DoE, 2008, p7)

The Learning Programme Guidelines for Mathematical Literacy (DoE, 2005) also appears to follow a connected approach, however seemingly more focused on the mathematics than the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008), when the document claims that Mathematical Literacy aims to develop four important abilities:

1. The ability to use basic mathematics to solve problems encountered in everyday life and in work situations.
2. The ability to understand information represented in mathematical ways.
3. The ability to engage critically with mathematically based arguments encountered in daily life.
4. The ability to communicate mathematically. (DoE, 2005, p8)

In the above stated aims the focus tends to be on mathematics used in real-life situations and the social communicative world. The view in the Learning Programme Guidelines for Mathematical Literacy (DoE, 2005) is further described in the following quote:

> The emphasis in learning should be on enabling learners to develop mathematical knowledge while dealing with issues, rather than on applying mathematics after learning the basics. (DoE, 2005, p8)

The Teacher Guide for Mathematical Literacy (2006, p4) describes the role of the Mathematical Literacy teacher with respect to the relationship between context and mathematics as follows:

> The challenge for you as the teacher is to use situations or contexts to reveal the underlying mathematics while simultaneously using the mathematics to make sense of the situations or contexts and in so doing develop in your students the habits or attributes of a mathematically literate person. (DoE, 2006, p4)

This view indicates a preference for a focus on the context above merely the application of mathematics.

The quotes from the South African policy document (DoE, 2003a) and guideline documents (DoE, 2008; DoE, 2005; DoE, 2006) mentioned previously pointed out that Mathematical Literacy includes both a mathematical and/or contextual emphasis of the notion of Mathematical Literacy. Overall, Mathematical Literacy, if linked to the literature on mathematical literacy discussed in the previous

section, can be interpreted within a frame that foregrounds the context (Steen, 2001; Skovsmose, 1992) or the mathematics (Pugalee, 1999).

3.2.1 Mathematical Literacy teaching approaches advocated in policy documents

Three main Mathematical Literacy teaching approaches appear to be visible within the curriculum documents. Evidence and the explanation of the three approaches are given below. The teaching approaches are the following:

1. A teaching practice where the focus is on the context and the mathematics is used to solve a contextual problem
2. A teaching practice where the context and mathematical content appear to be presented in an interconnected manner
3. A teaching practice where the focus is on the mathematical content and the context is used as a vehicle to teach the mathematics

3.2.1.1 Mathematical Literacy teaching practice with emphasis on context

Presenting the first teaching approach, the NCS for Mathematical Literacy (DoE, 2003a) appears to be influenced by Steen's definition (2001) of quantitative literacy since the policy document emphasizes that the Mathematical Literacy teaching approach should be anchored in context when it states 'teachers engage with context rather than applying mathematics' (DoE, 2003a, p42).

The approach appears to be that Mathematical Literacy teachers need to engage and understand a context with the intention of solving a problem within the context. To solve the problem the teacher needs to select the appropriate mathematical content in order to resolve the contextual problem. Aspects of Steen's view (2001, p5) - that quantitative literacy should be presented within an authentic context – are present in some of the documents:

> The subject … must provide authentic opportunities for the learners to work towards achieving critical outcomes. (DoE, 2005, p11; DoE, 2003a, p10)

Christiansen (2009) critiques the tension between the contextual teaching approach and the mathematically organized Mathematical Literacy curriculum in the following quote:

> By claiming that it is about life-related topics, the curriculum renders the underlying (mathematical) organising principles of the content invisible to the learners (and possibly to some teachers, too), who therefore will not learn mathematics, unless the teacher is in a position to ensure coherence and progression of mathematical concepts. The learner who thinks that AIDS is the topic, when generally it is about reading graphs, will get it wrong, yet the curriculum does not encourage that the learner is given the necessary guidance to develop the mathematical concept of graphs. (Christiansen, 2009)

A danger noted in the literature is if the context is foregrounded to such an extent that the mathematical focus is neglected; in such a case the Mathematical Literacy curriculum aims will not be met. Tension and problems might arise if teachers do not understand the mathematical learning

outcomes, assessment standards and progression stated in the Mathematical Literacy curriculum (DoE, 2003a).

3.2.1.2 Mathematical Literacy teaching practice with emphasis on content and context

The second teaching approach can be described as the interconnected approach and appears to be followed in the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008) where the focus is both on the context and the mathematical content. The document claims mathematics should be used to make sense of real-world contexts; further the contexts determine the content that is needed (DoE, 2008, p7). The integrated approach is also emphasized in the Learning Programme Guidelines for Mathematical Literacy (DoE, 2005) when the document claims that Mathematical Literacy aims to develop four important abilities (DoE, 2005, p8) – discussed on page 27 - connecting mathematics and real-world contexts. The view in the Learning Programme Guidelines for Mathematical Literacy (DoE, 2005) claims that the preferred learning focus should be to facilitate the learning of mathematics whilst dealing with real-life issues (DoE, 2005, p8). The emphasis is therefore on both content and context linked together.

Further support for this linked emphasis comes from comparing the learning outcomes of mathematics and Mathematical Literacy (DoE, 2003a; DoE 2003b), as in Table 1. The mathematics and Mathematical Literacy curricula, at first glance, show a vast overlap since the four learning outcomes have similar topics. However, the Mathematical Literacy curriculum links the mathematical concepts to contexts (LO1, LO2), different orientations and positions (LO3) or application of the mathematical concepts (LO4). The statements that refer to contexts are noted in bold in Table 1.

	MATHEMATICAL LITERACY	**MATHEMATICS**
LO1	NUMBER AND OPERATIONS IN CONTEXT: The learner is able to use knowledge of numbers and their relationships to **investigate a range of different contexts** which include financial aspects of personal, business and national issues.	NUMBER AND NUMBER RELATIONSHIPS: When solving problems, the learner is able to recognize, describe, represent, and work confidently with numbers and their relationships to estimate, calculate and check solutions
LO2	FUNCTIONAL RELATIONSHIPS: The learner is able to recognise, interpret, describe and represent various functional relationships to solve problems in **real and simulated contexts**	FUNCTIONS AND ALGEBRA: The learner is able to investigate, analyse, describe and represent a wide range of functions and solve related problems.
LO3	SPACE, SHAPE AND MEASUREMENT: The learner is able to measure using appropriate instruments, to estimate and calculate physical quantities and to interpret, describe and represent properties of, and relationships between 2D-shapes and 3D-objects, **in a variety of orientations and positions**	SPACE, SHAPE AND MEASUREMENT: The learner is able to describe, represent, analyse and explain properties of shapes in 2-dimensional and 3-dimensional space with justification.
LO4	DATA HANDLING: The learner is able to collect, summarise, display and analyse data and to **apply knowledge** of statistics and probability to communicate, justify, predict and critically interrogate findings and draw conclusions.	DATA HANDLING AND PROBABILITY: The learner is able to collect, organize, analyse and interpret data to establish statistical and probability models to solve problems

Table 1 Learning outcomes of Mathematical Literacy and mathematics

Furthermore, the Mathematical Literacy curriculum can be described as 'less densely packed (hence slower paced) and less content specific' (Graven and Venkat, 2007, p72) than the mathematics

curriculum. The 'lack of content specification' involves a 'lack of clear mathematical progression from grade 10 to grade 12' (Graven and Venkat, 2007, p72). Teachers have to be able to distinguish what is mathematically expected from the learners in each grade, and have to introduce contextual progression, therefore more complex context situations, across the three years of the FET band. This interconnected orientation aligns with the second teaching approach since it calls for both contextual and mathematical progression.

3.2.1.3 **Mathematical Literacy teaching practice with emphasis on mathematics**

Contradicting the integrated view described above, the third teaching approach supports the view that the Mathematical Literacy curriculum learning outcomes and assessment standards (DoE, 2003a) appear to have a predominantly mathematical nature as seen in aspects of the curriculum specification described in Table 1, although the guideline documents on planning, assessment and classroom practice (DoE, 2008; DoE, 2005; DoE, 2006) call for an interconnected relationship between context and content. The Mathematical Literacy curriculum learning outcomes (DoE, 2003a) tend to indicate that the context is used as a vehicle to explain and teach the mathematics.

I agree with the view of Christiansen (2006) that the nature of the Mathematical Literacy curriculum, based on the Mathematical Literacy learning outcomes and assessment standards, might be described as largely mathematical:

> It (NCS for Mathematical Literacy) has an obvious focus on mathematical skills and concepts throughout … its content is distinctly mathematical. (Christiansen, 2006, p10)

Christiansen maintains this view in 2009 in her article in which she claims that the Mathematical Literacy curriculum is less driven by everyday applications, and hence more driven by mathematics, than implied by the purpose statement of the NCS for Mathematical Literacy (DoE, 2003a):

> The curriculum is largely organized around mathematics which is often not of utility in everyday practices. As a result, the NCS renders invisible to the learners the organizing principles of the content, and thus is dis-empowering. (Christiansen, 2009)

In conclusion, it might be noted that the curriculum documents (DoE, 2003a; DoE, 2008; DoE, 2005; DoE, 2006) convey mixed messages on how to teach Mathematical Literacy, in particular with respect to the relationship between context and mathematical content. Interpretation of the policy is likely to be mixed since the teaching focus might be either on the context, the mathematics contents or both. Venkatakrishnan and Graven express the following view:

> It would appear that there are mixed messages within the Department of Education's documentation for Mathematical Literacy. Whether educators will give more emphasis to context-specific problem-solving using mathematics, or to the mathematics involved in solving contextual problems remains unclear at this stage.
>
> (Venkatakrishnan and Graven, 2006, p20)

The ‘newness’ of the subject with reference to pedagogy and assessment has allowed a wide spectrum of interpretation of the curriculum aims and teaching of the subject with respect to how context and content link together. The result is that teachers are likely to structure their teaching practice in a direction according to their own interpretation of the policy documents. According to empirical data on Mathematical Literacy classroom practice collected by Graven and Venkat (2007) there is evidence of a spectrum of Mathematical Literacy teaching practices, ranging from mathematical to contextual orientations. The context or the mathematical content might be foregrounded alternatively in or across Mathematical Literacy lessons. Therefore, classroom practice might foreground the mathematics or the context at different stages of teaching. The three teaching approaches discussed previously in this section can be expanded to fit in with the spectrum of teaching agendas developed by Graven and Venkat (2007).

The next section will focus on Mathematical Literacy teaching practice which will include a discussion on the spectrum of teaching agendas developed by Graven and Venkat (2007). The teaching agendas focus on the relationship between context and mathematical content in the Mathematical Literacy classroom.

3.2.2 The teaching of Mathematical Literacy

3.2.2.1 The relationship between context and mathematical content

Graven and Venkat (2007) developed an emerging pedagogic spectrum of agendas used in the teaching of Mathematical Literacy based on empirical data. The spectrum of agendas strongly link to Mathematical Literacy teachers’ interpretation of the relationship between context and mathematical content when teaching Mathematical Literacy. This led to different ‘pedagogic spaces in which teachers navigate their teaching across a spectrum of agendas’ (Graven and Venkat, 2007, p74). The authors developed a spectrum of four agendas linked to Bernstein’s theory (1982, 1996), namely:

1. Context driven agenda (by learner needs)
2. Content and context driven agenda
3. Mainly content driven agenda
4. Content agenda

The spectrum of four agendas for the teaching of Mathematical Literacy is summarised in Table 2. The above spectrum of teaching agendas (Graven and Venkat, 2007) has links to earlier calls in South Africa for the teaching of contextualised mathematics. Adler et al. (2000) noted that the teacher, when integrating across learning areas ‘needs to be able to zoom in on the mathematics and out again repeatedly, and it is essential to maintain a balance between the two.’

This view of ‘zooming in and out’ is relevant in the spectrum of teaching agendas, since the mathematics and the context may be foregrounded alternately. Adler et al. (2000) make the point that when the mathematics is ‘overshadowed by the theme, the conceptual development of mathematics

might not be supported' and, on the other hand, 'it is easier to maintain a mathematics focus, but this occurs at the expense of extended integrated and thematic work' (Adler et al., 2000, p9). A mathematical focus is easier than a contextual focus since it is structured and clearer to follow.

1. Context driven (by learner needs)	**2. Content & context driven**	**3. Mainly content driven**	**4. Content driven**
Driving agenda: To explore contexts that learners **need** to interact and engage with in their lives (current everyday, future work & everyday, and for critical citizenship) and to use maths to achieve this.	Driving agenda: To explore a context so as to deepen maths understanding and to learn maths (new or GET) **and** to deepen understanding of that context.	Driving agenda: To learn maths and then to apply it to various contexts.	Driving agenda: To give learners a 2nd chance to learn the basics of maths in GET band.
Pedagogic demands: Involves identifying contexts/ scenarios needed for the above agenda. Teaching needs increased discussion of contexts and critical engagement with them and the mathematics embedded in them. (E.g. when tax formulae change, who benefits most?) Teaching might require revisiting or learning new maths but largely insofar as it will service critical engagement with and understanding of the context.	Pedagogic demands: Involves selecting real contexts (possibly edited or adapted) that enable the above agenda. Teaching needs discussion about contexts but this must be balanced with revising maths and learning new maths in new ways. Contextual and mathematical learning need to balanced and connected in a dialectical relationship that enable the agenda.	Pedagogic demands: Involves selecting contexts that GET maths can be applied to (contrived or more real) and editing these to enable application appropriate to the level of learning. Teaching focuses on mathematical learning and its use in applications and doesn't necessarily require much discussion of context.	Pedagogic demands: Involves revision of GET maths without the need for pedagogic change except in relation to slower pacing. Contexts do not feature much except in relation to their use in teaching GET basics (e.g. in the case of fractions - using cakes for understanding fractions).

Table 2 Abridged version of the spectrum of agendas for the teaching of Mathematical Literacy (Graven and Venkat, 2007)

The agendas on the left of Table 2 focus on contextual understanding and analysis; on the other end of the spectrum mathematics is foregrounded. A teacher might move from one agenda to another at different stages of teaching within or across lessons presented.

According to Graven and Venkat (2007), the rhetoric of the NCS for Mathematical Literacy (2003a) promotes the left-hand agendas of teaching within the Context driven and Content and context driven agendas. Furthermore, the Mathematical Literacy curriculum, namely the learning outcomes and assessment standards, push towards the right-hand agendas of teaching Mathematical Literacy within the Mainly content driven and Content driven agendas, with some curriculum examples fitting in the middle of the spectrum of teaching agendas.

Graven and Venkat (2007) argue that the Context driven and Content and context driven teaching agendas support the implementation of Mathematical Literacy as a subject 'which can potentially change learner ways of participating in both the classroom and in the world' (Graven and Venkat, 2007, p83). They also note that Mathematical Literacy learners in their sample mostly had negative experiences of mathematical learning in the General Education and Training (GET) band. The teaching of mathematics in grades 8 and 9 relate strongly to teaching in the Mainly content driven and Content driven agenda since these two agendas have a largely mathematical focus. The authors suggest that in order to break this negativity and to deliver Mathematical Literacy outcomes, Mathematical Literacy teaching should focus on the Context driven and Content and context driven agendas by changing learners' experiences with respect to mathematics.

The Content and context agenda portrays the relationship between the mathematical content and the context in the teaching of Mathematical Literacy as a dialectical relationship (Graven and Venkat, 2007). They argue that the view with respect to the interconnected relationship between the context and the mathematical contents reflects the view of the Department of Education of how Mathematical Literacy should be taught. According to the Teacher Guide (2006) the role of the Mathematical Literacy teacher is:

> … to use situations or contexts to reveal the underlying mathematics while simultaneously using the mathematics to make sense of the situations (DoE, 2006, p4)

Furthermore, the curriculum guideline 'that teachers engage with context rather that applying mathematics already learned to the context' (DoE, 2003a, p42), shows a preference for the focus on the context when compared with the application of mathematics using the context as vehicle orientation. This again suggests that the agendas with a contextual focus are preferable to the agendas with a mathematical focus.

Overall then, the preferred approach appears to be that Mathematical Literacy teachers (and learners) have to develop the ability to engage and understand contexts with the intention of solving a problem within the context. The context should determine the embedded mathematical content needed to solve the problem. The selection of the appropriate mathematical content to solve the contextual problem might vary from person to person since there might be more than one way to approach a particular situation. Further, the mathematical calculations should be linked back to the context and inform the context. Teachers need to both have sound mathematical knowledge and an understanding of the contexts to teach Mathematical Literacy in line with curriculum aims.

The pedagogic spectrum of agendas framework is a useful framework to use for this research study since my evidence from the ACE Mathematical Literacy teachers pointed to a foregrounding of context and content at different times when they described Mathematical Literacy and in the ways they planned to teach and present Mathematical Literacy lessons. In this study I used the spectrum of

agendas to classify the classroom practice of the Mathematical Literacy teachers according to the four agendas, and to follow their movement over time (if any) across the spectrum of agendas. The teachers that I included in my research appeared not to fit straightforwardly into the four agendas described in the spectrum of teaching agendas. In my research I identified areas where the described agendas could be expanded to accommodate the empirical data that emerged as part of this research study. This suggests issues in terms of the application of the pedagogic spectrum of agendas framework to the ACE Mathematical Literacy teachers who were part of this study.

The issues and areas of limitation were related to the types and cognitive levels of questions included in assessment tasks and ethical or moral values discussions in the Mathematical Literacy classroom. The data obtained in this study gave information on the types of questions Mathematical Literacy teachers included in assessment tasks and the cognitive level of questions. Ethical and moral discussions emerged from the context on the practice of smoking that was handed out to the teachers on the ACE Mathematical Literacy course. The literature on these two themes is discussed in the next two sections.

3.2.2.2 The types of questions and the levels of questions

The empirical data collected for the study indicated that the teachers included contextual and mathematical questions in the classroom assessment tasks, but that these questions were largely not structured to enhance the connection between context and mathematical content as discussed in the previous sections. Furthermore, the cognitive levels of questions were by and large set at a relatively low level. This observation led me to further investigate literature on the assessment of Mathematical Literacy.

The questions used for Mathematical Literacy tasks could largely be described as either mathematical or contextual questions. The following statement gives the Department of Education's position on assessment of Mathematical Literacy as captured in the Subject Assessment Guidelines for Mathematical Literacy January 2008:

> When teaching and assessing Mathematical Literacy, teachers should avoid teaching and assessing mathematical content in the absence of context. At the same time teachers must also concentrate on identifying in and extracting from the contexts the underlying mathematics or content. Assessment in Mathematical Literacy needs to reflect this interplay between content and context. (DoE, 2008, p7)

The above quote emphasizes the view that context and content are interconnected.

The Mathematical Literacy taxonomy (DoE, 2008, p 27-28) further supplies information on the level of cognitive demand of questions for assessment tasks. According to the Subject Assessment Guidelines (2008, p12) each question in examination papers should integrate assessment standards from more than one learning outcome. Furthermore, each question should include sub-questions at different levels of the Mathematical Literacy assessment taxonomy.

The Subject Assessment Guidelines document (DoE, 2008, p 27-28) proposes the following framework for assessment in Table 3:

	Level of Assessment	**Description of the task**	**Percentage Allocation for grade 12 Exam**
1	Knowing	Basic calculations, know and use of basic formulae, read information of a table	30%
2	Applying routine procedures in familiar contexts	Perform well-known procedures in familiar contexts. Learners know what procedure is required from the way the problem is posed. All information is immediately available to the learner.	30%
3	Applying multistep procedures in a variety of contexts	Solve problems using well known procedures. The procedure is not immediately obvious from the way the problem is posed. Learners will have to decide on the most appropriate procedure to solve the solution to the question. One or more preliminary calculations might be needed before determining a solution.	20%
4	Reasoning and reflecting	Pose and answer questions about what mathematics they require to solve a problem and then select and use that mathematical content. Interpret the solution they determine to a problem in the context of the problem and where necessary adjust the mathematical solution to make sense in the context. Critique solutions. Generalise patterns and make predictions.	20%

Table 3 Mathematical Literacy Assessment taxonomy (DoE, 2008).

The cognitive level of the questions increase from low level questions on the 'knowing' level to high level questions on the 'reasoning and reflecting' level. The Subject Assessment Guidelines state the following:

> Assessment can be pitched at different levels of cognitive demand. On the one end of the spectrum are tasks that require the simple reproduction of facts while at the other end of the spectrum, tasks requiring detailed analysis and the use of varied and complex methods and approaches. (DoE, 2008, p8)

Steen's view that quantitative literacy involves making decisions using 'real data and uncertain procedures…and elementary mathematics' (Steen, 2001, p6), suggests the need for reasoning when making decisions. Venkat et al. (2009) hold the following view:

> Reasoning comes into play across all levels and in both domains: context and mathematics. (Venkat et al., 2009, p8)

Reasoning appears to be a necessary tool where mathematics and the everyday contexts are linked and decisions are made; it is inherent to the nature of Mathematical Literacy.

The empirical data showed the inclusion of low-level reflective questions. These questions could not be classified as level 4 questions since the Department of Education's assessment taxonomy suggests that 'reasoning and reflection' questions ask for higher-order cognitive skill. According to the above quote, Venkat et al. (2009) make reference to different levels of cognitive demand when reasoning within a context, in other words this might lead to low level and high(er) level 'reasoning and reflecting' questions. Furthermore, the authors also warn against 'over-scaffolding of questions' since this might reduce the cognitive demand intended for a question.

My earlier discussion highlighted the possibility that some teachers teach Mathematical Literacy within a mathematical frame in which contexts figure to a limited extent. This makes the Mathematical Literacy taxonomy problematic, hence I decided to include Stein, Schwan-Smith, Henningson and Silver's cognitive framework for mathematical tasks (2000) as part of the literature study. The framework has some parallels with the Mathematical Literacy taxonomy. The framework in Table 4 defines mathematical tasks in terms of cognitive demands as lower-level and higher-level demand tasks.

	Cognitive demand	**Type of task**	**Description of task**
1	Lower–level demand	Memorization	Reproduction of facts, rules, formulas, definitions and other knowledge; questions are not ambiguous
2	Lower–level demand	Procedures without connections	Algorithmic, require limited cognitive demand and no explanation
3	Higher-level demand	Procedures with connections	Tasks have suggested pathways to follow, but require some degree of cognitive effort since decisions have to be made as to which procedures to follow
4	Higher-level demand	Doing mathematics	Requires students to investigate and understand the mathematics and relationships and asks for complex and non-algorithmic thinking since no pathway is suggested by the task.

Table 4 The level of cognitive demand of tasks (Stein et al., 2000)

The lower–level demand tasks can be classified as memorization tasks and procedures without connections. These questions are similar to questions on 'knowing' and 'applying routine procedures in familiar contexts' level (DoE, 2008). The higher-level demand tasks are classified as procedures with connections and doing mathematics (similar to questions on 'applying multistep procedures in a variety of contexts' and the 'reasoning and reflection' level, DoE, 2008). Procedures with connections require 'the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas' (Stein et al., 2000, p16). Doing mathematics tasks require considerable cognitive demand.

The Department of Education's assessment taxonomy for Mathematical Literacy can be described as an assessment framework used to classify mathematical questions embedded in context. On the other hand, Stein et al.'s (2000) assessment framework is intended for the classification of mathematical tasks. In this study I have used the Department of Education's assessment framework for Mathematical Literacy, as well as Stein et al.'s framework, because the tasks set by the Mathematical Literacy teachers often included pure mathematical questions or mathematical questions where the context was used as a vehicle to explain the mathematics.

The spectrum of teaching agendas developed by Graven and Venkat (2007) includes reference to assessment in the Mathematical Literacy classroom. With the research done as part of this study I intend to shed more light on assessment, especially with reference to the types of questions and the cognitive levels of questions used within Mathematical Literacy classroom tasks. The types of questions also gave an indication of the Mathematical Literacy teaching agenda(s) (Graven and Venkat, 2007) the teachers preferred to work in.

3.2.2.3 **Social and moral values**

The focus on social and ethical values emerged from the empirical data collected for this study. I stated in chapter 1 that data on smoking levels in different countries were provided to teachers on the ACE Mathematical Literacy course. Teachers were provided with contextual data on the percentages of people smoking in countries from all over the world. Some teachers introduced contextual class discussions on the practice of smoking. The discussions led to issues with respect to the reasons and effects of smoking, and whether a person should engage in the practice of smoking or not.

Schools are key institutions where learners receive education in skills, knowledge, values and attitudes (DoE, 2003a). The education system in South Africa acknowledges the wide diversity of indigenous knowledge systems in the South African context through which people make sense of and attach meaning to the world in which they live (DoE, 2003a, p4). This includes social and cultural practices that developed over thousands of years. The Manifesto on Values, Education and Democracy (DoE, 2001, p9-10) states the following about education and values:

> Values and morality give meaning to our individual and social relationships. They are the common currencies that make life more meaningful than might otherwise have been. An education system…must enrich the individual and, by extension, the broader society.
>
> (DoE, 2003a, p4)

In line with the aims of creating a new democratic South Africa, the NCS for Mathematical Literacy (DoE, 2003a) states critical and developmental outcomes which describe the kind of citizen that the South African education system would like to bring into being. A critical outcome that might indicate a link to social values is:

> Participate as responsible citizens in the life of local, national and global communities.
>
> (DoE, 2003a, p2)

Learners frequently face real-life decisions inside and outside the school context. The decisions have to be responsible and might be set against the background of a set of social and ethical values. According to the NCS for Mathematical Literacy policy document (2003a, p9), learners are required to 'critically analyse everyday situations and solve problems.' It is envisaged that a learner will develop into a 'self-managing person, a contributing worker and a participating citizen' (DoE, 2003a, p9). This aim of the Mathematical Literacy curriculum clearly links to the principles of the South African education system as embedded in the Constitution of the Republic of South Africa (Act 108 of 1996).

Tuana (2007) claims that moral literacy, in addition to language and numerical literacy, are important elements of education. She argues that the important role of moral literacy cannot be ignored to fully answer the challenges of a changing world (Tuana, 2007, p1). Her view is that education should be seen as 'reinforcing and enhancing the skills begun at home' (Tuana, 2007, p2), functioning as an

extension of home and community environments. According to Tuana (2007) moral literacy involves three basic components - namely ethics sensitivity, ethical reasoning skills and moral imagination. Tuana (2007) further states:

> All of these abilities interact and mutually reinforce one another. The development of an understanding of ethical reasoning skills can serve to heighten ethics sensitivity, and so on. While there is no fixed formula for the order in which these traits are taught, what is fixed is that moral literacy requires the development of all three these competencies …. Students could be able to 'sort through the process of moral reasoning about a case, but still be unable by themselves to identify whether a situation involves an ethical issue. (Tuana, 2007, p2)

Ethics sensitivity involves at least three major components (Tuana, 2007, p2):

1. the ability to determine whether or not a situation involves ethical issues
2. awareness of the moral intensity of the ethical situation
3. the ability to identify the moral virtues or values underlying an ethical situation

Ethics sensitivity with respect to the issue of the practice of smoking might include the effects of smoking on the individual, the influence of smoking on other people, in other words passive smoking, the effect of smoking of pregnant or lactating woman on unborn or breastfeeding babies, and the type of substance that is smoked. The emphasis on values will be embedded in the social and cultural practices of the community within which the practice of smoking occurs. Tuana claims 'communities hold significantly different beliefs and values' (Tuana, 2007, p3); therefore, the 'moral intensity' with respect to the practice of smoking might differ from community to community. Some of the ACE Mathematical Literacy teachers showed ethical sensitivity when they engaged in ethical discussions with the learners regarding the practice of smoking, but no explicit reference was made to the contextual data.

Ethical reasoning skills also involve at least three different abilities (Tuana, 2007, p3):

1. An understanding of the various ethical frameworks
2. The ability to identify and assess the validity of facts relevant to the ethical situation
3. The ability to identify and assess the values that a individual or group holds to be relevant to the ethical issue under consideration

Tuana (2007) also points out:

> Ethical reasoning skills also include critical reasoning skills … Moral literacy includes not only identifying the relevant facts, but making sound inferences from those facts … Moral literacy also includes assessing values. (Tuana, 2007, p5)

In the smoking context ethical reasoning skills would refer to the ability to make a valid ethical judgement with respect to the data presented (facts) and community values on the practice of smoking. The data indicated the total smoking percentages per country, as well as the smoking percentages for men and women. Critical reasoning, based on the interpretation of evidence and

rooted in the social values and beliefs of the community the individual is part of, was notably absent in the empirical research data.

According to Tuana moral imagination is:

> The ability to imaginatively discern various possibilities for acting in a given situation and envision the potential help and harm that are likely to result from a given situation. The moral imagination refers to the blend of affective and rational processes that contribute to the imagination. (Tuana, 2007, p5)

Moral imagination refers to the 'image' of probable actions that might develop as a result of the blend of 'reason and emotions' within a given context (Tuana, 2007, p5). This might lead to a sense of 'personal ownership' (Tuana, 2007, p6) of our actions and therefore a sense of responsibility. Ownership might suggest possibilities for personal decision-making and actions, which align with the view of the Department of Education with respect to the development of a 'responsible citizen' (DoE, 2003a, p2) and a 'self-managing person' (DoE, 2003a, p9). It must be noted that the empirical data showed more evidence of 'affective' and less evidence of 'rational' processes in terms of 'possibilities for action'.

I agree with Tuana (2007, p1) that 'living an ethical life is an achievement, and one that must be carefully and continuously cultivated.' The South African curriculum suggests that the education we provide to our learners should include reference to ethical and moral issues and discussions. In doing this we will make learners sensitive to such issues and help them to develop reasoning skills to make responsible and competent choices in life. These aims relate closely to the rhetoric of the Mathematical Literacy curriculum.

The spectrum of teaching agendas developed by Graven and Venkat (2007) does not include direct reference to ethical or moral values discussions that could arise from the context discussed in the Mathematical Literacy classroom. The context driven agenda, however, refers to 'discussion of contexts and critical engagement with them'. The critical democratic orientation often includes an ethical and moral perspective in the literature (Skosmose, 1992; Vithal, 2006), but it is not specifically pointed out in the description of the agendas. However, the contextual agendas in this study link to ethical positions in relation to positions advocated in the literature.

I intend to make suggestions on the adaptation and extension of Graven and Venkat's spectrum of agendas (2007) to accommodate reference to ethical and /or moral discussions that might occur when a context is dealt with. This includes commentary on how the teachers incorporated moral and/or ethical foci when teaching learners in the Mathematical Literacy classroom regarding a particular context.

3.2.3 Integration with Wenger's social theory of learning (1998)

The empirical data collected for the purpose of this study related to a sample of the ACE Mathematical Literacy teachers' notions of the nature and purpose of Mathematical Literacy and their Mathematical Literacy teaching practice and its development over time.

Wenger's learning component of meaning might be explained as the development of an understanding and experience of the new Mathematical Literacy curriculum as meaningful. The teachers' understandings of the curriculum were heard in conversations amongst teachers about ways to teach the curriculum. Orientations to Mathematical Literacy teaching practice were captured in the data on lesson plans, classroom assessment tasks and lesson presentations. Following the discussion of key issues relating to the nature and the teaching of Mathematical Literacy in this chapter, I focused on the relationship between context and mathematical content, the types and cognitive levels of questions in assessment tasks and the emergent theme of social and ethical values.

I also explored the ways in which understanding and experience of the Mathematical Literacy curriculum related to Mathematical Literacy classroom practice. Teachers appeared to interpret their sense of understanding and experience of the Mathematical Literacy curriculum and its outcomes concerning the relationship between context and content in a range of ways.

In the next chapter the research design and methodological approach are discussed in detail. This includes discussion on the nature and assumptions of the study, links to the ACE Mathematical Literacy course, reference to my dual role as presenter and researcher on the course, discussion of the data collection process and instruments, and the selection of case studies for the research.

4 Research design

In this chapter I discuss the research design of this research study. The discussion includes a description of the nature of the research study, reference to the assumptions and limitations of the study, the description and the time frame of the data collection process over 16 months, the issue of the confidentiality and informed consent of participants involved, the selection of case studies to be analysed for the purposes of the study, and a critical discussion of the data collection instruments.

The empirical data collected as part of the study provides a picture on the ACE Mathematical Literacy teachers' developing understandings of Mathematical Literacy. The data gives information on the teachers' understanding and interpretation of the Mathematical Literacy curriculum and evidence of their sense of Mathematical Literacy teaching. The data was collected over 16 months; hence it offers a reflection of the learning component of meaning (Wenger, 1998) over time. The analysis on the meanings and shifts in meanings of Mathematical Literacy over time provided answers to the first research question. The proposed lesson plans, assessment tasks developed for the lessons, and in particular the video tapes of the lessons presented by the ACE Mathematical Literacy teachers, shed light on the Mathematical Literacy teaching practice of the teachers included in the study. The analysis focuses on the relationship between mathematical content and context in the understanding of the nature of Mathematical Literacy and the teaching of the subject. Aspects of the relationship were evident in the portfolio tasks submitted as part of the course, Mathematical Literacy lesson plans and lesson presentations, and in the assignments and worksheets prepared for the lessons. The classroom assessment tasks and video tapes of lessons also provided information on the type and cognitive level of questions used in Mathematical Literacy tasks/worksheets. As stated in the previous chapter, the theme of ethical and moral values emerged from the analysis of the class discussions on the contextual data on smokers' that was used in the observed Mathematical Literacy lessons. These discussions link to the learning component of practice (Wenger, 1998) and give answers to the second research question. According to Wenger (1998) the learning components of meaning and practice are interconnected in a dynamic process of learning within socially constructed communities of practice. The dynamic process refers to shifts in the relationship between meaning and practice over time.

4.1 Background of the study

This research study investigates Mathematical Literacy teacher learning within the empirical field of in-service training practice (INSET). The study could be described as a qualitative research study that follows an 'anti-positivistic' approach (Opie, 2004). Opie describes the 'anti-positivistic' approach as 'research which seeks softer facts and insights into how an individual creates, specifies and interprets the world in which they find themselves'. The data analysis could be described as a combination of approaches. The analysis could largely be described as inductive in the sense that it moved from

specifics to analytic generalizations (Lincoln & Cuba, 1985 as taken up in Hatch, 2002), e.g. the sensitivity to the emergence of moral and ethical dimensions. The analysis could also be viewed as typological, e.g. with respect to the use of the spectrum of teaching agendas (Graven and Venkat, 2007) as an analytical tool to classify the Mathematical Literacy teachers' teaching practice.

The study focused on the interpretations and understandings and teaching practices of two ACE Mathematical Literacy teachers within the ACE Mathematical Literacy course. Denscombe (2007) stated that:

> Case studies focus on one (or a few) instances of a particular phenomenon with a view to providing an in-depth account of events, relationships, experiences or processes occurring in that particular instance. The aim is to illuminate the general by looking at the particular.
>
> (Denscombe, 2007, p35)

In this research study the teachers' understanding of the relationship between context and mathematical contents in the Mathematical Literacy classroom was analysed with respect to the learning components of meaning and practice (Wenger, 1998). The investigation of the two case studies could be described as 'discovery led' (Denscombe, 2007) since the two case settings were described, explored and compared in order to learn from the similarities and differences within and between them. The relationships and processes were compared for each case, and compared across the two cases in order to search for emerging themes and shifts in the understanding of meaning and practice over 16 months. One of the aims of this study was to search across the two cases for areas of 'relatability' (Opie, 2004) - a way in which existing theory could be tested and recommendations made for the expansion of theory, specifically with reference to the spectrum of teaching agendas developed by Graven and Venkat (2007).

The research study drew on data generated through assessment tasks handed in as part of Module 1 of the ACE Mathematical Literacy course, namely the module 'Introduction to Mathematical Literacy', two informal questionnaires, an interview and observation of the selected teachers over a period of 16 months. The assessment tasks were part of the Module 1 course requirements, but the informal questionnaires, interviews and classroom practice observations were added for research purposes.

The ACE Mathematical Literacy formal course outcomes were shared in chapter 1. These outcomes underpin the outcomes for all four course modules. The course outcomes that specifically link to Wenger's learning components (1998) of meaning and practice are:

1. provide a course which covers issues relating to the NCS within an OBE approach
2. offer the student teacher a range of teaching resources which he/she can critically evaluate and incorporate into his/her own teaching programme
3. develop an integrative approach to learning and teaching

The first course outcome is focused on the learning component of meaning. The second outcome suggests a connection to the components of meaning and practice; 'critically evaluate' suggests a link to meaning and 'teaching programme' to practice. The third course outcome ties to the integration and interconnection of meaning and practice.

The outcomes for Module 1: Introduction to Mathematical Literacy was shared in chapter 1. The proposed outcome of critical analysis of national and international literature on mathematical literacy and the South African Mathematical Literacy curriculum documents and the critical analysis of issues related to the contextualisation of mathematics relate to the understanding and experience of the Mathematical Literacy curriculum as meaningful. Therefore it can be connected to Wenger's learning component of meaning (1998). Furthermore, the discussion on the implementation of the Mathematical Literacy curriculum and the design of learning units for use in South African schools, together with the analysis of learning and teaching support material and exemplar matric Mathematical Literacy examination papers, link to the learning component of practice (Wenger, 1998).

ACE Mathematical Literacy teachers received the NCS for Mathematical Literacy (DoE, 2003a) in the first session of the course, 13 February 2007. Articles by Steen (2001) and Pugalee (1999) relating to international conceptions of mathematical literacy were handed out to all teachers in the second session of the course (20 February 2007).

4.2 Assumptions of the study

In this study the primary units of analysis were the meanings and practices generated over time by the selected teachers within their participation in the ACE Mathematical Literacy classroom. The classroom was comprised of ACE Mathematical Literacy teachers and the presenter of the sessions. There are two assumptions under which the research was undertaken, namely:

1. Teacher learning would be promoted by participating within the community of practice of the ACE Mathematical Literacy classroom (Wenger, 1998). According to Graven (2005, p142) 'learning would be enabled and supported by creating a learning environment where collegiality, co-operation, support and a strong sense of community is encouraged'. Hence members of the community of practice would provide scaffolding for teacher learning.
2. The implementation of the new curriculum with respect to the nature and purpose of the subject Mathematical Literacy and the implementation of classroom practice as prescribed by the Department of Education involved teacher learning. As noted in chapter 2, Wenger (1998) states that learning involves changes in knowledge (meaning), roles (community), 'ways of being' (identity) and 'ways of doing' (practice).

4.3 Dual role as presenter and researcher of the ACE Mathematical Literacy course

In this research project I had the role of course coordinator and presenter of the ACE Mathematical Literacy course, as well as researcher. The ACE Mathematical Literacy classroom could be described as one of the communities of practice (Wenger, 1998) where the teachers and I learned from each other and shared experiences. I was an observer of and a participant in the community of practice of ACE Mathematical Literacy teachers. From a methodological viewpoint I needed to wear two hats in order to distinguish clearly between the two roles:

1. Developer and presenter of the Module 1: Introduction to Mathematical literacy of the ACE Mathematical Literacy course. As developer of the module I structured the module with specific outcomes in mind (Chapter 1), and my aim as presenter/facilitator of the module was to achieve the desired outcomes. As module facilitator I had access to all assessment tasks the teachers handed in as part of the module requirements.
2. Qualitative researcher: In addition to the data obtained from the formal assessment tasks, I also collected informal information through two questionnaires, an interview, the videotaping of teaching practice, feedback during lecture sessions, and comments made during group work and report back sessions. As a researcher I had to critically reflect on the achievement of course and module outcomes. The reflection included analysis in order to be self-critical about instances where the module and course aims did not seem to be achieved.

The dual nature of analyzing the situation from the different perspectives as facilitator of and researcher on the course did involve tension, but contained potential for a powerful praxis (Graven, 2002). The critical lenses led to insight and information gained from the formal assessment tasks, informal questionnaires, interviews, lesson presentations and interactive classroom sessions. The knowledge was used to critically reflect on whether and to what extent the course, and in particular the module outcomes were achieved. This reflective information can influence the way in which the course and/or module could be re-structured to achieve the desired outcomes since the design and presentation of the course aims to maximise teacher participation and learning. The interaction between the two roles occurred on an ongoing base during the pilot run of the course, and in the reflection and possible course restructuring afterwards.

I had to take into account that my presence as researcher, course presenter and assessor in the ACE Mathematical Literacy classroom might have an ‘observer effect’, as described by Denscombe (2007). There was evidence that some teachers behaved in ways that they anticipated might be expected of them in the context of the ACE Mathematical Literacy classroom. This occurred in spite of my emphasis throughout the presentation of the ACE course that teachers should share their actual individual views and experiences.

4.4 The central data collection tool: The rate of smoking amongst adults data

The central data collection tool that was used for the research was based on contextual data on the rate of smoking amongst adults in different countries (Table 5). The smokers' data was taken from a text book Mathematical Literacy Grade 10, Learner's Book (OBE for FET) (Vermeulen, De Vries, Main, Smallbones and Mdlalose, p 50). The presentation of the smokers' data was contextually located.

Rate of Smoking amongst adults

Tobacco is the cause of death of 560 people every hour, or 13400 people every day or 4,9 million people each year. The World Health Organisation says that tobacco is the only product that *will* cause the death of one in every two people who use it.

Country	**Total %**	**Men**	**Women**	**Country**	**Total %**	**Men**	**Women**
Albania	39,0	60,0	18,0	Israel	28,5	33,0	24,0
Algeria	25,2	43,8	6,6	Italy	24,9	32,4	17,3
America	23,6	26,9	21,5	Japan	33,1	52,8	13,4
Argentina	40,4	46,8	34,0	Kenya	49,4	66,8	31,9
Australia	20,5	21,0	18,0	Mexico	34,8	51,2	18,4
Bangladesh	38,7	53,6	23,8	Namibia	50,0	65,0	35,0
Brazil	33,8	38,2	29,0	Nauru	54,0	61,0	47,0
Britain	26,5	27,0	26,0	Netherlands	33,0	37,0	29,0
Cambodia	37,0	66,0	8,0	Nigeria	8,6	15,4	1,7
Canada	25,0	27,0	23,0	Norway	31,5	31,0	32,0
China	35,6	66,9	4,2	Pakistan	22,5	36,0	9,0
France	34,5	38,6	30,3	Russia	36,5	63,2	9,7
Germany	35,0	39,0	31,0	Singapore	15,0	26,9	3,1
Greece	38,0	47,0	29,0	South Africa	26,5	42,0	11,0
Guinea	51,7	59,5	43,8	Spain	33,4	42,1	24,7
Haiti	9,7	10,7	8,6	Sweden	19,0	19,0	19,0
India	16,0	29,4	2,5	Switzerland	33,5	39,0	28,0
Indonesia	31,4	59,0	3,7	Thailand	23,4	44,1	2,6
Iran	15,3	27,2	3,4				

Table 5 Smokers' data (Rapport, 20/10/2002, taken from Vermeulen et al., 2005, p50)

This data collection tool was centrally used in three of the data collection instruments: Portfolio 1 (20 February 2007), Assignment 2 (11 September 2007) and the videos of classroom practice (September, October 2007). Furthermore, the data tool was also linked to the following data collection instruments: Questionnaire 1 (20 February 2007), Questionnaire 2 (handed in after lesson presentation) and the personalised interviews (May 2008).

The smokers' data context was appropriate for the course since it provided a rich context which teachers could interpret in various ways when teaching Mathematical Literacy. The choice of the data was based on wanting to encourage ACE Mathematical Literacy teachers to critically engage with a context (DoE, 2003a, p42; DoE, 2005, p8), and then to think about ways to use mathematics to understand and analyse it. Whilst readings and discussions in the ACE Mathematical Literacy course promoted the idea of integrating/connecting content to context, teachers were simply given the smokers' data and asked to reflect on it through lesson planning and integrate it into teaching as they felt appropriate. Therefore, the choice to focus either on the mathematics or the context of smoking when teaching was left to the teacher.

In the first session of the course, ACE Mathematical Literacy teachers were asked to develop questions for the smoking context, discuss teaching and learning strategies and possible resources for teaching within the context (Portfolio 1, 20 February 2007). Later, in September 2007, the ACE Mathematical Literacy teachers were requested to use the same data on the rate of smoking amongst adults (Table 5) and formally design a lesson and a worksheet (Assignment 2, 11 September 2007) for the given context. The teaching of the designed lessons of the seven ACE Mathematical Literacy teachers who taught Mathematical Literacy in 2007 was videotaped (September, October 2007). The purpose of repeating the use of the same contextual data was to see whether the teacher would, eight months later, change his/her ideas or planning on how to teach the Mathematical Literacy lesson through a focus on the kinds of questions and discussions selected. The focus was to see whether a change occurred with respect to contextual or content foregrounding within the lesson planning, and if so in which direction and to what extent the movement was. In other words, I wanted to determine whether and if so, how, the teachers' meaning and practice (Wenger, 1998) changed over time.

The smokers' data context was a useful context for the purposes of this study. The empirical data suggested that, in practice, some teachers chose to teach within the context and aimed to select mathematics embedded in the context. Other teachers chose to initiate their lesson with the mathematics and use the context as a vehicle to do the mathematics.

Interrogation of the smokers' data

The smokers' data was grouped in terms of total percentage of population who smoked, percentage of men who smoked and percentage of women who smoked. According to the smokers' data in Table 5 the total percentage of smokers for a country is in most cases the arithmetic mean of men and woman

smokers. In these instances, the sizes of the male and female population are accepted as equal in size. This is, for example, not the case for Brazil where the total percentage of smokers in Table 5 is 33.8%, but the arithmetic mean of men and woman who smoked is 33.6%. The 33.8% figure indicates that Brazil has a slightly skewed population in terms of gender. For most countries in the table, the total percentage can be calculated with the following formula:

$$\text{Total percentage} = \frac{\%\,men + \%\,women}{2}$$

It is useful to note that there exists an imbalance between the male and female smokers in the given data. The male rate of smoking is generally higher than the female rate of smoking. This occurrence is applicable in most countries, except for Norway and Sweden. In Sweden the percentage male and female smokers is equal. Therefore, there are broad patterns of gender-based differences in the data. The reasons for the prevalence of the differences and the direction of the imbalance can therefore be examined as part of the analysis of the data in the classroom.

The analysis of the data on the rate of smoking amongst adults with respect to gender, eastern and western countries, developed and developing countries and culturally-sensitive smoking patterns related to gender roles are possible avenues a teacher could investigate when following a context-orientated teaching approach. The issues described here might become foregrounded when teaching Mathematical Literacy using the smokers' data within the Contexts driven agenda (agenda 1) or Context and content agenda (agenda 2) as described by Graven and Venkat (2007). In the Context agenda the focus is to explore the context since the 'teaching needs increased discussion of contexts and critical engagement with them and the mathematics embedded in them' (Graven and Venkat, 2007, p76). When working in the Context driven agenda the focus is therefore on the critical engagement, analysis and understanding of the context and the mathematics is used in service of the context. The analysis and interrogation of the context will be less emphasised when a teacher works within the Content and context driven agenda since contextual and mathematical learning is connected and balanced (Graven and Venkat, 2007, p76). The teaching focuses more on mathematical learning and less on contextual discussions when the teacher prefers to teach within the Mainly content driven agenda. In the Content driven agenda contextual discussion is minimised, but a range of possibilities exist for using this data.

4.5 Data collection process

The data collected for the purpose of this study may be classified as information focusing on the initial knowledge and teaching practice of the ACE Mathematical Literacy teachers in the early data sources, and data on the development of meaning and practice of the teachers over a period of 16 months. I refer to the initial information as baseline data, and to the information acquired over time as continuous data. The purpose for the collection of data over time was to see if any changes were

visible over time, and if so, to explore the direction or movement of the change. The data collected for the research study could be classified either as part of the course requirements of the ACE Mathematical Literacy course or as data useful for my role as researcher on the course. The nine data collection instruments are summarized in Table 6:

	Data collected as course presenter	**Data collected as researcher**
Baseline data February 2007	ACE Teacher Profile form: teachers' personal information Portfolio 1: teachers' description of Mathematical Literacy, activity/teaching ideas using the smokers' data	Questionnaire 1: teachers' informal views on the planned lesson for Portfolio 1 (using the smoker's data)
Continuous data March 2007-May 2008	Portfolio 3: teachers provide a description of the nature and the purpose of Mathematical Literacy; difference between Mathematical Literacy and school mathematics Assignment 1: teachers provide a description of the nature and the purpose of Mathematical Literacy; difference between Mathematical Literacy and school mathematics Assignment 2: teachers' lesson outcomes, prior knowledge, assessment tools, lesson plan and worksheet using the smokers' data	Video of classroom practice: lesson presentation of lesson planned for Assignment 2 Questionnaire 2: teachers were probed concerning his/her development of meaning and practice with respect to Mathematical Literacy Interview: personalised interview to probe the development concerning the teachers' Mathematical Literacy meaning and practice

Table 6 Data collected for the research

The data collected as course presenter (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007; Assignment 2, 11 September 2007) were assessed as part of the ACE Mathematical Literacy course. As course assessor I aimed to see the dialectical Mathematical Literacy teaching approach advocated by the NCS for Mathematical Literacy (DoE, 2003a) and other curriculum guideline documents (DoE, 2008; DoE, 2005; DoE, 2006). I searched for evidence that the ACE course teacher planned to teach, assess and teach the subject in a way that linked and integrated mathematical calculations to everyday contexts. This view as course assessor is part of the tension I experienced with my dual role as course presenter/assessor and researcher. As researcher on the ACE Mathematical Literacy course I investigated the spectrum of teaching agendas (Graven and Venkat, 2007) that the ACE teachers used when planning, assessing and teaching Mathematical Literacy.

4.6 Confidentiality and ethics

The informed consent of each ACE Mathematical Literacy teacher for participating in the research project and videotaped lessons was obtained. Letters of consent were distributed to all concerned parties prior to videotaping of the lessons. Consent was obtained from:

1. The learners and the parents of the learners (Appendix A)
2. The school principal (Appendix B)
3. The ACE Mathematical Literacy teacher (Appendix C)

The letters informed all the parties of the aim of the research and requested permission to observe and video-tape the teachers and the learners and to use the collected data for research purposes. Participants were assured that the names of the schools, teachers and the learners would to be kept anonymous and that the data used in the research would be kept under lock and key. Anonymity and confidentiality of all participants were assured in all written reports produced from the research, including this dissertation.

4.7 Selection of ACE Mathematical Literacy teachers for the research study

Data was initially collected for all nineteen students that enrolled for the ACE Mathematical Literacy course. However, I wanted to do a deeper analysis and comparison with a restricted number of case studies and therefore I had to make a deliberate choice of cases selected on the basis of known attributes and analysis of the early data. The criteria used for the selection of cases is described and justified below.

As indicated in chapter 1, school-based assessment of teaching practice was not an ACE Mathematical Literacy course expectation; therefore all teachers were not observed teaching. The first selection of teachers took place when the class visits and video taping of classroom practice were conducted as only seven of the group of nineteen teachers who enrolled for the course were teaching Mathematical Literacy during 2007. These seven teachers were selected and visited in their classrooms and their lesson presentations were videotaped for research purposes. Each of these teachers completed Questionnaire 2 after the lesson presentations. The written tasks and lesson presentations of the seven student teachers were analysed to determine whether and how their understanding of Mathematical Literacy and of teaching the subject had changed over time.

After the preliminary analysis of the written tasks and classroom practice of the seven teachers were completed, I selected the data of two ACE Mathematical Literacy teachers to investigate further and as the focus of my research. The selection was conducted on the basis of practical consideration and the theoretical issues (Denscombe, 2007) I wanted to investigate in relation to the spectrum of agendas (Graven and Venkat, 2007). The criteria that underlay my selection of teachers rested on the following:

1. Complete responses on questionnaire forms and interviews.

Teacher R and Teacher M did not participate fully at all times. Teacher R left out some responses on Questionnaire 2. Teacher M was not prepared for his lesson presentation since his focus at that time appeared to be on the completion of grade 12 portfolios for hand-in at the District. Teacher R and Teacher M were removed from the sample.

2. Movement in relation to the ACE Mathematical Literacy teachers' understanding and teaching practice over time.

The focus of the study was to investigate the relationship between mathematical content and the context, and how the understanding of the relationship impacted on teaching practice, over time. I searched for movement and a change in meaning and/or practice over time. Teacher C initially preferred to work with the focus on the mathematics; sixteen months later the teacher still preferred to focus on the mathematics in the Mathematical Literacy classroom. Teacher C was removed from the sample since I wanted to investigate change in meaning and/or teaching practice over time.

3. Different directions of movement in relation to the ACE Mathematical Literacy teachers' understanding and teaching practice over time across the cases selected.

Teacher B initially worked within the mathematics, but his understanding of the meaning and teaching practice appeared to move in a more contextual direction. Teacher A, Teacher X and Teacher L's understanding and teaching of Mathematical Literacy were initially contextualized, but changed to become more mathematically orientated. I selected Teacher B as a case I wanted to investigate further since the movement of his practice appeared to be from the mathematical to the contextual. I had to make a choice between the data collected of Teacher A, Teacher X and Teacher L in order to choose a second case study to focus on. The last criterion determined the choice between these three teachers.

4. Purposive selection of a case that is intrinsically interesting (Denscombe, 2007)

This criterion allows for the selection of the case on the grounds of interesting and rich data which is more informative with respect to the research problem. The case could be described as a 'telling case' and it makes the research a more exciting experience for the researcher and the reader.

Teacher A's choices in relation to the contextual discussion in her classroom highlighted a range of issues within a focus on context. Her classroom practice was interesting in relation to contextual issues in that she asked learners to bring different drugs to school which people can smoke, for example dagga, Taiwan (a white powdery substance) and snuff. The contextual discussion led to an interesting value-discussion on smoking. Teacher X and Teacher L introduced a class discussion on the dangers of smoking and referred incidentally to values and health issues with respect to the practice of smoking, but to a lesser degree than Teacher A. The 'rich data' that was collected in Teacher A's classroom exemplified issues well. The theme of

values and ethics that developed within the context of Teacher A's Mathematical Literacy lesson emerged as an interesting aspect of this study and asked for further probing. Hence the data on Teacher A was chosen to be analysed in more depth, although the 'values and ethics' theme was relevant to Teachers X and L as well.

The above selection criteria resulted in my analysis focusing on the case studies of Teacher A and Teacher B. As indicated previously, multiple methods were used to capture the complex interlinkage of meaning and teaching practice with respect to Mathematical Literacy. The research design rests on 'tracking' the way the smokers' data is understood and used to teach Mathematical Literacy over time. The smokers' data is used with other data instruments to verify and support my interpretations. The specific time frames for the data collection process, the participants involved and the data collection instruments are discussed in the next section.

4.8 Time frame for the data collection process

The nine data collection instruments in Table 6 included formal written ACE assessment tasks, informal written tasks collected for research purposes, interviews and videos of classroom practice. Table 7 provides an overview of the data collected for both Teachers A and B.

	Date	Data collection instrument	'Smoking-data related'	Type
1	13 February 2007	ACE teacher profile form		Informal written
2	20 February 2007	Portfolio 1	√	Formal written
3	20 February 2007	Questionnaire 1	√	Informal written
4	13 March 2007	Portfolio 3		Formal written
5	10 April 2007	Assignment 1		Formal written
6	11September 2007	Assignment 2	√	Formal written
7	September/October 2007	Video of classroom practice	√	Classroom practice
8	September/October 2007	Questionnaire 2	√	Informal written
9	13 May 2008	Interview		Informal oral
	24 May 2008	Interview		Informal oral

Table 7 Time frame for data collection

The dates indicated for the formal tasks represented ACE course hand-in dates. In the next section the data collection instruments are discussed in more detail.

4.9 Discussion of data collection instruments

As indicated in Table 7 the nine data collection instruments could be described as formal written data that was collected as part of the INSET course, informal data that was collected outside the course requirements and videos of classroom practice. The data collection instruments that linked to the smokers' data are the main focus of the study with the other sources providing important background detail. These instruments are presented in this section. The data collection instruments that did not directly link to the smokers' task can be found in Appendix D, E, F, G, and H.

4.9.1 Portfolio 1 (20 February 2007)

Portfolio 1 (20 February 2007), a written ACE Mathematical Literacy assessment task, was used as a baseline data collection instrument and was the key data resource for the study. The task given to the teachers had two parts: In the first part the ACE Mathematical Literacy teachers were asked to give a description of Mathematical Literacy in their own words. In the second part of the task each ACE Mathematical Literacy teacher received the contextual data concerning statistics on smokers from countries over the world (see Table 5). Teachers were asked to analyse the data and think about ways to teach Mathematical Literacy using the smokers' data. The planning focused on the development of questions for the context, teaching and learning strategies and resources that could be used when teaching. Teachers were subsequently asked to use the same contextual data to do a lesson plan and teach a Mathematical Literacy class of a grade of their choice. The task given to the Mathematical Literacy teachers was as follows:

Portfolio 1	
Part 1: Give a description for Mathematical Literacy in your own words	
Part 2: Read and analyse the context given (see Table 5). You are asked to teach the context to a grade of your choice.	
1	Develop questions for the context given. The questions have to uncover the underlying mathematics in the context. State for which grade the questions are appropriate.
2	Discuss the teaching strategies you will use to enable learners to understand and solve the questions asked.
3	Discuss the learning strategies suitable for understanding the context.
4	Which resources could you use to teach the context?

Reflection on Portfolio 1

The task given to the ACE Mathematical Literacy teachers could be critiqued to be heavily biased towards the context. I purposefully designed the task in such a way to close the spaces for teaching in the purely mathematical Content driven agenda (Venkat and Graven, 2007) and to align the task with Mathematical Literacy curriculum expectations. The course aim was to guide the teacher to include both components of mathematics and context in their teaching. The choice of words was intentional in order to influence teachers to teach within the context. However, from a research perspective it has to be noted that if teachers had been given the smokers' data without the accompanying task, their classroom practice might have been different from the empirical data that was collected for this research study.

4.9.2 Questionnaire 1 (20 February 2007)

The informal questionnaire was included to obtain the ACE Mathematical Literacy teachers' informal views and reflections on the planned lesson using the smokers' data handed in as part of Portfolio 1. The questionnaire was conducted in the same ACE Mathematical Literacy session when Portfolio 1 was handed in. The following questions were asked with respect to the planning of a lesson using the data on the rate of smoking amongst adults:

Questionnaire 1	
1	Write down your thoughts on this task. How did you feel when you received the task on smoking data?
2	Have you had experience of teaching/learning with this task? If so, describe your experiences of teaching and of learning.
3	How does this task 'fit' or 'not fit' in with your ideas about Mathematical Literacy?

4.9.3 Assignment 2 (11 September 2007)

The task was again related to the smoking data (see Table 5). Similar to the task for Portfolio 1 (20 February 2007), Assignment 2 was strongly predisposed towards a contextual orientation. The task given to the ACE Mathematical Literacy teachers was structured as follows:

Assignment 2	
Question 1	
Study the above context. Design a lesson and refer to the following:	
1	Grade for whom the lesson will be taught
2	Learning outcome(s)
3	Assessment standard(s)
4	Lesson outcome(s)
5	Prior knowledge needed for the learners to gain from the lesson
6	Resources used
7	Introduction, body and conclusion of the lesson
8	Assessment tools during the lesson and for homework
Question 2	
2.1 Design a worksheet for a 50 - 60 minute lesson. Your worksheet must cohere with the following curriculum intentions in the Teacher Guide for Mathematical Literacy:	
The challenge for you as the teacher is to use situations or contexts to reveal the underlying mathematics while simultaneously using the mathematics to make sense of the situations or contexts, and in so doing develop in your students the habits or attributes of a mathematically literate person. (DoE, 2006, p4)	
You should also ensure that about 40% of your worksheet requires learners to perform multistep procedures and to reason and reflect on their work. Indicate your mark allocation.	
2.2 Give an example of a learner's answer that will get a 100%.	

Reflection on Assignment 2

The assignment was structured in such a way as to encourage the teachers to work in Agenda 2, which is the dialectical agenda as described by Graven and Venkat (2007). Part of the frame of the ACE Mathematical Literacy course was for the teachers to use and understand the NCS for Mathematical Literacy (DoE, 2003a) and other guideline documents (DoE, 2008; DoE, 2005; DoE, 2006). It might be noted that the ACE Mathematical Literacy teachers were given the context of smokers' data and then asked to design a worksheet in line with the curriculum intentions as taken up in the Teacher Guide for Mathematical Literacy (DoE, 2006).

The Mathematical Literacy taxonomy was also part of the structure provided by the curriculum documents, in particular the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008), and the ACE Mathematical Literacy course. It followed that the level of questions in the worksheet was prescribed to have 40% of all worksheet questions on a higher level of cognitive demand. This is the prescribed percentage allocation for questions on level 3 and 4 in grade 12 examinations (DoE, 2008, p 27-28).

4.9.4 Video of lesson presentation (September/October 2007)

I videotaped the lesson presentations of the seven teachers who taught Mathematical Literacy in 2007. The choice to videotape the lesson presentations based on the smoking data task was part of my role as researcher. I analysed the videotaped lessons to determine if and how the ACE Mathematical Literacy teacher had developed his/her understanding and learning of the meaning of Mathematical Literacy and how these meanings related to his/her teaching practice. I investigated how the ACE teacher dealt with the smoking context and the mathematical content in the Mathematical Literacy classroom, which component was foregrounded during the lesson, and the relationship between the context and the content. As before, the aim was to direct the ACE Mathematical Literacy teachers' planning and teaching to align with the Content and context driven agenda (Graven and Venkat, 2007), therefore teachers did not have an entirely 'open' choice'. Furthermore, I grappled with whether, and if so how, the problem posed by the context was analysed, interpreted and dealt with.

4.9.5 Questionnaire 2 (September/October 2007)

Questionnaire 2 was only distributed to the seven ACE Mathematical Literacy teachers whose lesson presentations based on the smoking data were videotaped. The questions for this questionnaire were structured to purposefully have the ACE Mathematical Literacy teacher reflect on his/her understanding and teaching with respect to Mathematical Literacy. Some of the questions were specifically linked to the teaching of the lesson using the smokers' data (see Table 5). Therefore Questionnaire 2 is directly linked to Portfolio 1 (20 February 2007), Questionnaire 1 (20 February 2007), Assignment 2 (11 September 2007) and the videos of lesson presentation (September/October 2007).

One of the aims of Questionnaire 2 was to probe whether, and if so, what, had changed over time for the teacher with respect to his/her own understanding and meaning of the nature and purpose of Mathematical Literacy. Another aim of Questionnaire 2 was to probe - if there was a change in meaning - whether, and, if so, how the teacher's expressed meaning related to his/her teaching practice. The meaning and teaching practice was linked to the teachers' understanding of the relationship between context and mathematical content. The following questions were included in the Questionnaire 2:

Questionnaire 2	
Question 1	
1	Explain the nature and purpose of Mathematical Literacy as you see it.
2	How do you think this is different to what you thought at the beginning of the year? (February 2007)
Question 2	
How do you feel about teaching Mathematical Literacy with the Smokers' data? (September 2007)	
Question 3	
1	Explain the difference between maths and Mathematical Literacy in your own words.
2	Explain how your teaching of Mathematical Literacy is different from your teaching of mathematics (in the past).
3	How has your teaching of Mathematical Literacy changed (if at all) over this year, that is, from the beginning of the year to now? (September 2007)
4	What do you attribute this change to?
5	Who do you discuss your Mathematical Literacy teaching with? Did you do this last year? Who do you draw on for your support?
Question 4: Teaching of the smokers' data lesson	
1	The lesson task specifically asked you to focus on context and content. How did you think about the relationship between context and content in the design of the lesson?
2	Can you tell me now, after teaching the lesson, how you see the relationship between context and content, in particular between the smokers' data and the mathematics?
3	At the start of the ACE Mathematical Literacy course we gave you the smokers' data. How do you think this lesson differs from how you would have used the smokers' data in a lesson at the start?
4	What aspects of the ACE Mathematical Literacy helped you to unpack or think about the smokers' data and how to use it in your teaching?

4.9.6 The data collection instruments not directly linked to the smokers' data

There are four data collection instruments listed in Table 7 which were not directly linked to the smokers' data, but were used as part of this research study. The instruments are:

1. ACE Teacher Profile form (Appendix D)
2. Portfolio 3 (Appendix E)
3. Assignment 1 (Appendix F)
4. Individual interviews with Teacher A and Teacher B (Appendix G, Appendix H)

The ACE Teacher Profile form (13 February 2007) gave information with respect to the background, teaching experience and training of the ACE Mathematical Literacy teachers. The other instruments supplied valuable data on the teachers' views with respect to the nature and purpose of Mathematical Literacy, the difference between mathematics and Mathematical Literacy and how Mathematical Literacy should be taught. Portfolio 3 (13 March 2007) and Assignment 1 (10 April 2007) were formal written assessment tasks handed in as part of the ACE Mathematical Literacy course requirements. The purpose of the individual interviews with Teacher A and Teacher B (May 2008) was to reflect on the nature of his/her learning with respect to his/her personal meaning and teaching practice of Mathematical Literacy. The design of the questions was done after a preliminary analysis of the data for Teacher A and Teacher B was completed in May 2008. The interview questions for each teacher show overlaps, but also differences in emphasis and direction of probing. The interview questions also indicate whether the focus of the question was on the learning component of meaning or practice (Wenger, 1998), technology or values.

In the next chapter the stories of the two ACE Mathematical Literacy teachers that were selected for the research study are shared. The stories are followed by an in-depth analysis and discussion of each case study.

5 Analysis

In chapter 2, I discussed Wenger's social framework for learning (1998) as a theoretical framework for this research study, and connected it to literature in the field of mathematical literacy in chapter 3. In chapter 4, the inductive qualitative methodological approach followed for the study was discussed. The research study focuses largely on the development of the following aspects for two case studies over 16 months:

1. Teacher understanding of the meaning of Mathematical Literacy with particular reference to the understanding of the new curriculum and ways of teaching the subject. The study focuses centrally on the understanding of the relationship between context and mathematical content.
2. The development of Mathematical Literacy teaching practice over time.

In this chapter, I present and analyse the development of Teacher A and Teacher B - two teachers enrolled for the ACE Mathematical Literacy course, over a period of 16 months. The two case studies of the teachers' understanding of the relationship between context and contents in Mathematical Literacy are analysed with respect to the learning components of meaning and practice (Wenger, 1998). The analysis for each case study is mainly done through the trajectory of their interaction with the smokers' data, but I also draw on other tasks and commentary where useful.

This chapter is structured as follows: The first section presents the story of Teacher A, followed by an overview of, and then detailed analysis of her story. Thereafter, Teacher B's story is presented, again followed by an overview of and then a deeper analysis of his story. The stories are told in a chronological sequence[3]. Some of the themes that are discussed in the analysis came up because the research questions were structured around the meaning and practice frame drawn from Wenger's theoretical framework (1998) and the literature study; other themes emerged from the data that was collected for the analysis.

The analysis for each teacher's story is broadly structured around the following themes:

1. The teachers' understanding of the nature and purpose of Mathematical Literacy. In the context of the research, the learning component of meaning is viewed as understanding and experiencing the new Mathematical Literacy curriculum as meaningful, as well as talk about ways of teaching the curriculum. I focused on teachers' willingness and competence to voice the nature and purpose of the subject in their own words as an indicator of their 'ownership' of meaning. The central focus is on the understanding of the new Mathematical Literacy curriculum with respect to the relationship between context and mathematical content.

[3] Quotes and answers to questions are given verbatim, and therefore they may include language errors since they were not edited.

2. The teachers' practice for the teaching of Mathematical Literacy. This component focuses on the planning and presentation of a Mathematical Literacy lesson. This section includes a discussion on the relationship between mathematical contents and context when planning and teaching a lesson, the nature and level of questions asked in Mathematical Literacy tasks and ethical and moral value discussions relating to the smoking context.

5.1 Teacher A's story

Teacher A's story is shared chronologically across the data collected through the data collection instruments discussed in chapter 4.

5.1.1 ACE Teacher Profile form

Teacher A was a mathematics and life sciences teacher who had been teaching for 9 years. She had been teaching grade 8, 9 and 10 learners. The year 2007 was her first year teaching Mathematical Literacy and she taught grade 10 learners. Her highest qualification was a Senior Teacher's Diploma, within which her major subjects were mathematics (year 3) and biology.

5.1.2 Portfolio 1 (20 February 2007)

Teacher A commented that she had access to the NCS for Mathematical Literacy (DoE, 2003a) prior to the handing in of Portfolio 1 (20 February 2007). Teacher A's comments about Mathematical Literacy often referred very directly to the curriculum documents. She commented, for example, that Mathematical Literacy helped in the development of a learner as a 'self-managing person' and a 'contributing worker', comments quoted directly from the NCS for Mathematical Literacy (DoE, 2003a). She described Mathematical Literacy in the first written task as follows:

> Mathematical Literacy teaches learners to cope with the outside world. It prepares and helps learners to deal with problems relating to real-life situations. Mathematical Literacy deals with the kind of mathematics that learners might need to use when they leave school and get a job, for example, they will learn about how to use money or how to control money, which is an important skill for anyone to have. Mathematical Literacy at the end of the day will ensure the development of critical thinkers who can take their place with confidence in modern society and ensure that South Africa plays a meaningful role on the global stage.

In the lesson plan using the data on smoking percentages for populations from all over the world (Table 5) Teacher A stated:

> Smoking has been a norm and has been/is being practised in our society. It's everywhere (used in all forms of media e.g. magazines, TV) hence creating the attitude amongst people of 'it's okay to smoke' and 'he is smoking, why can't I?' Smoking hazards are not widely promoted as smoking in general is portrayed in advertisements or in our daily lives.

In Portfolio 1 (20 February 2007) she included a sheet with two figures that 'show people smoking everywhere, anytime.' She also included a picture of a warning against smoking in a magazine and an article on the success of wearing nicotine patches to quit smoking. The article included a warning by

the Heart and Stroke Foundation regarding tobacco smoke. The warning in the magazine said 'smokers are 70% more likely, on average, to need root canal than those who never smoked.'

The second part of her lesson plan focused on the interpretation of the smokers' data in Table 5 and questions with respect to the data. Teacher A asked the learners to study the table and proposed the following activity for teaching Mathematical Literacy with the smokers' contextual data (Table 8):

	Questions for teaching activity
1	Which three countries have the highest percentage of smokers?
2	Which three countries have the lowest percentage of smokers?
3	What do you think could be the cause of the high smoking rate?
4	What is the difference in percentage rate in men and women smokers in South Africa?
5	Which country has the same percentage rate women and men smokers?
6	Which country has the highest percentage of men smokers?
7	Calculate the average percentage of men and women smokers.
8	Which country situated in the African continent has the highest total smoking rate?
9	Think of two ways in which the smoking rate amongst adults can be reduced?
10	From the data given draw a pie/bar graph illustrating the difference in the percentage rate amongst smokers. Choose 5 countries

Table 8 Teacher A: Activity (Portfolio1)

Teacher A did not include calculators or any other technology as resources when planning the lesson and I noted that the nature of the questions in the activity did not appear to require calculator use.

5.1.3 Questionnaire 1 (20 February 2007)

In Questionnaire 1 (20 February 2007) Teacher A gave her informal view on how the task to design a lesson using the smokers' data 'fitted in' with her notion of Mathematical Literacy. She stated:

> In Mathematical Literacy you would deal with stats of number of people who smokes and can be represented in a table form, graphs and be interpreted.

Teacher A shared her personal view on smoking, commenting on possible health problems for smokers:

> I think high percentage of people around the world are smoking, which in the long run, the society can get diseases due to smoking, and people will die in large numbers, e.g. from liver cancer.

She stated that her prior experience of teaching in relation to the issue of smoking took place in the life sciences classroom. This could have been be a factor in her comments, as she taught 'the consequences of smoking which might affect the respiratory system, illnesses, diseases that might be caused by smoking.'

Teacher A indicated that her own experience of learning with respect to the practice of smoking occurred when she 'read through the media, newspapers, and magazines'.

5.1.4 **Portfolio 3 (13 March 2007)**

In Portfolio 3 (13 March 2007), Teacher A described Mathematical Literacy in the written task as:

> A habit of mind and an approach to problems that employs and enhances both statistics and mathematics. Mathematical Literacy prepares and helps learners to deal with problems relating to real-life situations. For people to function effectively in today's world, Mathematical Literacy is as essential as verbal literacy. It involves real data and procedures which are not prescribed. It is integral to all subjects i.e. it is flexible and can be used in different contexts, e.g. biology, history, geography, arts and economics. Mathematical Literacy empowers people by giving them tools to think for themselves, to ask intelligent questions of experts and to confront authority confidently.

Furthermore, Teacher A claimed that the purpose of Mathematical Literacy is:

> To give learners full access to the school curriculum and to participate fully in the adult world. Mathematical Literacy ensures the development of critical thinkers who can take their place with confidence. Our workforce needs citizens who can adapt to new technologies, identifying problems and communicating their findings using symbols, graphs, tables, pictures and words.

When asked to describe the difference between maths and Mathematical Literacy she stated:

> Mathematical Literacy is inseparable from context, contents develops from context. It is driven by issues that are important to people in their lives and work, therefore teachers should choose contexts that is meaningful to learners. School maths involves simplified numbers and straight forward procedures but require sophisticated abstract concepts. Abstraction gives mathematics power.

5.1.5 **Assignment 1 (10 April 2007)**

Teacher A described Mathematical Literacy in Assignment 1 (10 April 2007) in the same way as she did in Portfolio 3 (13 March 2007), but added:

> Mathematical Literacy is always applied to real and relevant situations where learners develop the ability to use numbers and relationships to do calculations and monitoring the financial aspects of personal and business issues, e.g. one can learn how Mathematical Literacy can help to start up a tourist company. It deals with the kind of mathematics that you might need to use when you leave school and get a job, e.g. one can learn how to use mathematics to control money and this is an important skill for a manager.

She referred to the NCS for Mathematical Literacy (DoE, 2003a) when she described the aim of Mathematical Literacy as the development of 'a self-managing person, a contributing worker and a

participating citizen'. Furthermore, when asked to point out the difference between 'school maths' and Mathematical Literacy, Teacher A stated:

> When teaching Mathematical Literacy is when you involve maths acting in the world where appropriate skills are used in different contexts. Inseparable from context, content develops from context driven by issues that are important to people in their lives and work. While teaching maths there is a disconnection from meaningful context which results in an absence of common number sense; it cannot be used in different contexts. It has a historical focus on school based knowledge where it involves simplified numbers and requires sophisticated abstract concepts.

5.1.6 **Assignment 2 (11 September 2007)**

In Assignment 2 (11 September 2007), Teacher A proposed the following lesson outcomes, prior knowledge linked to the lesson outcomes, and assessment tools for the lesson using the smokers' data (Table 9):

Lesson outcomes	**Prior knowledge**	**Assessment tools**
At the end of the lesson learners should be able to: Compare the rate of smoking in countries that are listed in the table Calculate percentage, ratio Determine the mean, median, mode range Draw and interpret frequency table Draw and interpret graphs according to given information	Learners are: To name different types of cigarettes they know Count the numbers in each box Tell what they think would happen to a person who smokes a lot To tell who smokes more between males and females, youth and adults To tell which places in South Africa they think have more smokers	Worksheet and memorandum

Table 9 Teacher A: Lesson outcomes, etc (Assignment 2)

In Assignment 2 (11 September 2007) Teacher A suggested the following development of the lesson (Table 10) in a written task:

Lesson plan		
	What the teacher will do	What the learners will do
Introduction	Show learners kinds of tobaccos i.e. cigarettes, dagga Explain disadvantages of smoking, its effects on peoples' lives	After observation, tell whether smoking is good or bad and give/tell how many people in their families smoke
Body of the lesson	Smoking hazards are not widely promoted as smoking in general is portrayed in advertisements or in our daily lives. Quote from a magazine: Smokers are 70% more likely, on average, to need root canals than those who never smoked. According to the table countries like Nauru is having the highest percentage of smokers (54, 1%) compared to other countries, China has the highest smokers of men, followed by Kenya. Haiti is having the least total percentage of smokers. According to research of the World Health Organisation it says that tobacco is the only product that will cause death of one in every two people who uses it. The ratio will be 1:2. Albania is having men at 60, 0, women 18, 0. Then the ratio is 10:3. Calculation of percentages Calculation of the mean, mode and median. First rearrange the scores and then find the middle most score. Calculation of the range. Drawing of a bar graph.	
Conclusion	Two pictures are shown to the learners to show the two sides to smoking: Picture 1: How to handle holiday stress It shows two people in a fight and two onlookers to the fight. The two onlookers are smoking and seem relaxed. The teacher states: Some people are smoking for relieving stress. Some are smoking for fun, peer pressure. Picture 2: Quitters: Stick to it This is a discussion on the addictive nature of smoking and the success of quitting smoking by wearing nicotine patches. The teacher says: Smoking, if prolonged, can cause diseases such as lung cancer. If the lungs collapse individuals can die. Symptoms-lungs change colour from reddish to brownish. The teacher concludes: … but at the end of the day it's not healthy for the body because of its contents.	
Resources	Picture from magazines, calculator, table of data	

Table 10 Teacher A: Lesson plan (Assignment 2)

As part of Assignment 2 (11 September 2007) Teacher A developed the following worksheet for the lesson (Table 11):

Worksheet

Question 1

Study the following table on rate of smoking amongst adults and answer the questions.

1.1 Which 3 countries are having the highest percentage of smokers? (3)

1.2 Which 3 countries are having the lowest percentage of smokers? (3)

1.3 What do you think could be the cause of the high smoking rate? (2)

1.4 Which country has the same percentage rate of men and women smokers? (1)

1.5 Calculate the percentage male smokers in Israel. (3)

Question 2

2.1 The ratio for Sweden: men : women is 19: 19, hence 1: 1

Calculate the percentage men: woman in South Africa, Argentina and Pakistan. (3)

2.2 Complete the following table: (6)

Number of Smokers	Tally	Frequency
Albania 39[4]		
Algeria 25		
Guinea 51		
Sweden 19		
Iran 15		
46		

2.3 Think of two ways in which the smoking rate amongst adults can be reduced. (4)

Question 3

3.1 From the data given draw a bar graph illustrating the difference in the percentage rate amongst smokers (choose any 6 countries) (10)

3.2 Estimate the total number of women who will be smoking by 2010 in South Africa. (2)

3.3 Take one cigarette, measure the length and calculate its circumference. (4)

Question 4

4.1 Calculate the mean percentage of women who smokes from the table. (4)

Table 11 Teacher A: Worksheet (Assignment 2)

Questions 1.1, 1.2, 1.3 and 1.4 in the above worksheet (Assignment 2, 11 September 2007) correspond with questions 1, 2, 3 and 5 respectively in the activity included for Portfolio 1 (20 February 2007). Teacher A provided a memorandum for the worksheet (Assignment 2,

[4] Total % figures for each country

11 September 2007). The memorandum is found in Figure 3 and Figure 4 (see pages 65 and 66). It must be noted that the numbering of the questions in the worksheet does not correspond with the memorandum provided. Question 1 in the worksheet corresponds with the answer supplied in number 2 in the memorandum, etc.

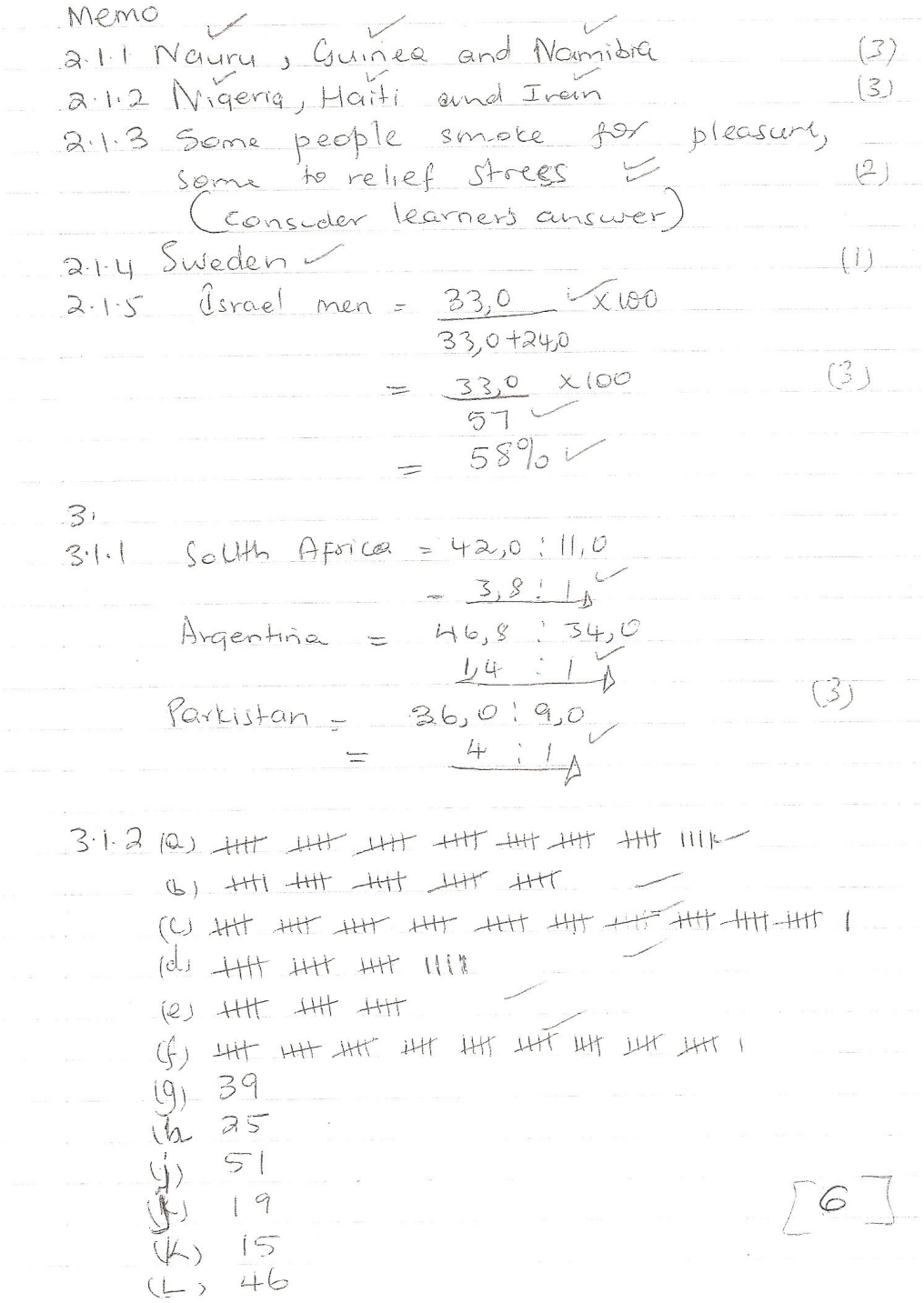

Memo
2.1.1 Nauru, Guinea and Namibia (3)
2.1.2 Nigeria, Haiti and Iran (3)
2.1.3 Some people smoke for pleasure, some to relief stress (2)
(consider learners answer)
2.1.4 Sweden (1)
2.1.5 Israel men = $\frac{33,0}{33,0+24,0} \times 100$
$= \frac{33,0}{57} \times 100$ (3)
$= 58\%$
3.
3.1.1 South Africa = 42,0 : 11,0
= 3,8 : 1
Argentina = 46,8 : 34,0
1,4 : 1
Pakistan = 36,0 : 9,0
= 4 : 1 (3)
3.1.2 (a) 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |||
(b) 𝍸 𝍸 𝍸 𝍸 𝍸
(c) 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |
(d) 𝍸 𝍸 𝍸 |||
(e) 𝍸 𝍸 𝍸
(f) 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |
(g) 39
(h) 25
(i) 51
(j) 19
(k) 15
(l) 46
[6]

Figure 3: Teacher A Memorandum p1 (Worksheet for Assignment 2)

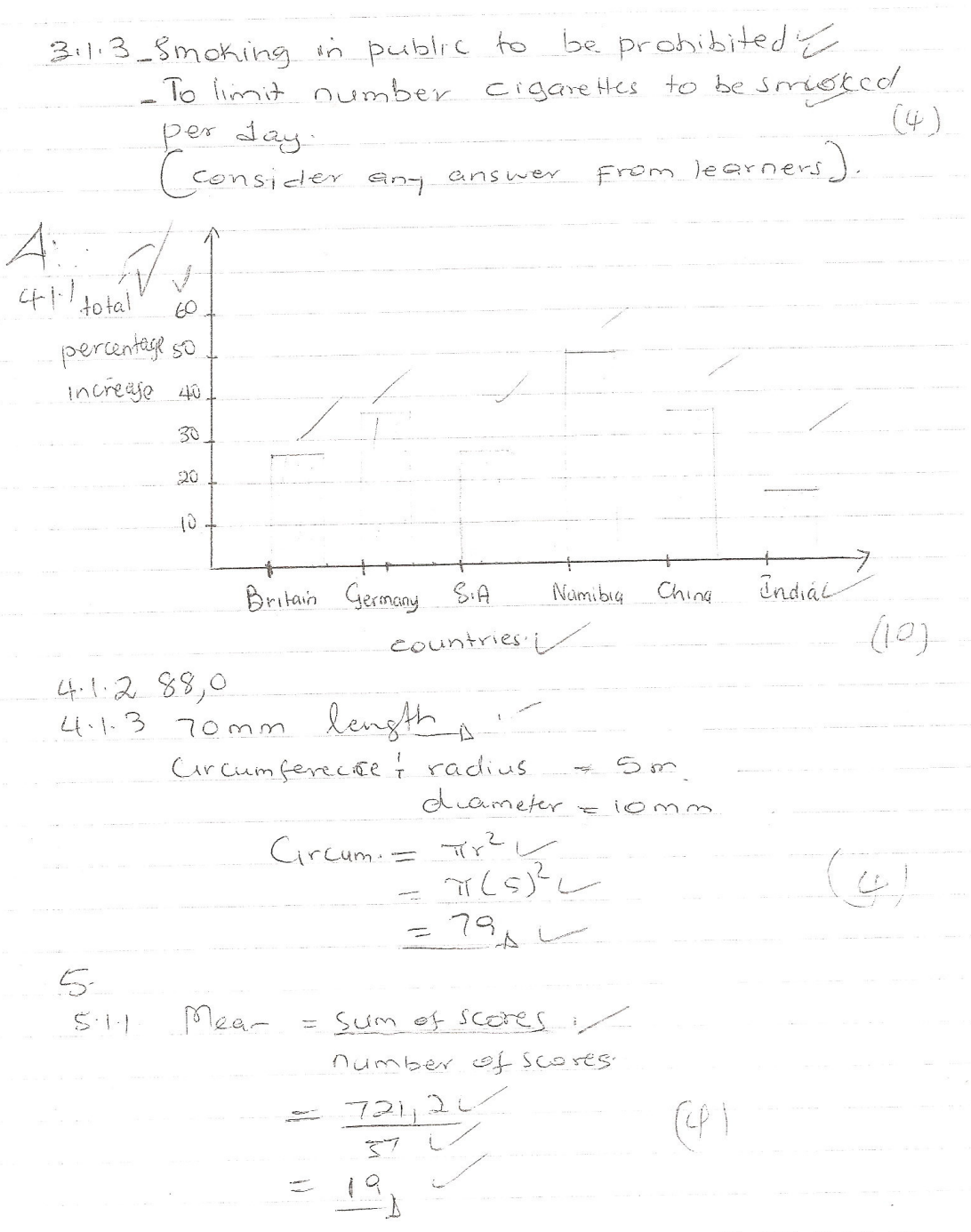


Figure 4: Teacher A Memorandum p2 (Worksheet for Assignment 2)

5.1.7 **Lesson presentation (2 October 2007)**

Teacher A presented the lesson above on the smokers' data (Table 5) on 2 October 2007. In the following section I describe the series of events that took place in the teaching of the planned lesson. Details were collected from field notes and the video-taped data.

The teacher introduced the lesson comparing the habit of smoking for girls and boys by asking 'Who do you think smokes the most, girls or boys?' and 'What about adults?' Learners responded by saying that boys and men smoke more than girls and women.

The teacher then asked: 'What do they smoke? Cigarettes, dagga? What else? Even drugs.' The she continued: 'Do you know of the dangers that you can face when you will be smoking? What could be the dangers of smoking?' She confirmed when the learners replied 'cancer', but then accentuated lung cancer and Tuberculosis. She then selected one learner whom she seemed to suspect to be smoking, a boy named Jack, age 18, and said: 'Think of him at age 80, think of him at age 30, at age 60.'

She continued the unpacking of the general smoking context, asking: 'Do you know the types of cigarettes?' The learners answered in the affirmative and she then pointed out:

> Then you are smokers. If you are smoking for your entire life it can cause health problems like cancer. You have lungs, when you are smoking...smoking...smoking, and if your lungs get affected they can be damaged. Now think of your lungs. What is the colour of your lungs? Reddish, pinkish? A normal person can have that colour. Now when you are smoking a cigarette for a longer time, your lungs can have cancer and if you have symptoms of cancer the colour is going to change from that reddish brownish to grayish. … And if they are mostly affected they will collapse. You can even die.

After the discussion on the dangers of smoking, the teacher changed the discussion from the smoking of tobacco to the smoking of other substances. She said: 'Joseph brought me another kind of stuff that you guys smoke. What is it? Dagga. You are smoking dagga. How do you smoke it?' Then followed a class discussion and a learner did a presentation on how a dagga roll is made. The learner said one should first remove the red pips from the green dagga leaves, then break a cigarette and mix the tobacco with the dagga leaves. The mixture is crushed and then rolled in newspaper or 'reezla' paper. The teacher again asked the question: 'What happens to your lungs?'

Then the teacher said: 'We also have the white stuff here that you smoke.' Teacher A referred to Taiwan, a drug named after the city it came from. Again one of the learners explained how the substance was prepared and used. The discussion moved on to the cost of these substances. Learners stated that the selling price of dagga was lower than the price of a cigarette in their community (R1 vs. R1,20).

The teacher again referred to the dangers of smoking, asking:

> Smoking into your body system. Do you think this is healthy? So you must stop. Because at the end of the day you will have lung cancer, throat cancer.

Teacher A handed out the rate of smoking data sheet at this point, before referring to another substance named snuff. She stated:

> We also have this traditional…what is it? We call it snuff. It is brownish. Who smokes it between girls and boys?

The learners agreed that more girls smoked snuff. The teacher stated:

> Some use it as a culture, some use it for stress. Relieving headache. What do you gain from this? Does your headache heal when you smoke this? We use it mostly in our culture. They just pinch it as a symbol of honoring the ancestors. They talk to them. When you feel you have a headache.

Gender differences in smoking habits, the nature of substances smoked, and the dangers of smoking were dealt with in the above discussion. Whilst the issue of gendered patterns of smoking related to the data sheet, no explicit link was made to the data. Teacher A concluded the reasons for smoking to be the following:

> Some smoke for fun. Peer pressure. You smoke because your friends are smoking. Some smoke to relieve stress. Some are having a headache. They use this.

The teacher moved back to the article on the rate of smoking. She emphasized the fact that people were dying from smoking and that one out of two people that smoke would die as a result of smoking. She made the statement personal when she said:

> If you girls are smoking one of every two will die. After reading this, do you think this is good? Boys, stop smoking. At the end the day you will be good citizens, good males who are healthy.

The teacher engaged with the general context on smoking for approximately the first 20 minutes of a 35 minute lesson before she moved on to the article on the rate of smoking. She asked the learners how the total percentage was calculated and illustrated it by referring to Albania and South Africa. The following formula was stated:

$$Total\ \% = \frac{\%\,men + \%\,women}{2}$$

The teacher requested the learners to calculate the percentage female smokers in Brazil. The following formula was given to the learners to work out the answer:

$$\%\ \text{ of Brazilian women smokers} = \frac{\%\,women}{\%\,women + \%\,men}$$

She demonstrated the calculation on the chalk board for the learners:

$$\frac{29\%}{29\% + 38.2\%}$$

$$= \frac{29\%}{67.2\%}$$

$$= 43\%$$

She went on to calculate the percentage of Brazilian male smokers in the same manner. She explained further to the learners that percentages always add up to 100%. Therefore, that the percentage men plus the percentage women add up to 100%, and that the percentage of Brazilian men smokers is 57%.

The teacher then asked the learners to obtain the mean of men smokers from the table. She gave them the following formula:

$$\text{Mean} = \frac{sum\,of\ scores}{number\,of\ scores}$$

The last activity required the learners to work with a calculator. However, only a few learners (3 of the 38 learners) used calculators to do the calculations. The other learners did mental calculations, which took them much longer. The teacher then asked the learners to calculate the mean percentage of men smokers of only the first four countries.

The teacher used resources linked to the lesson topic to make the lesson interesting and capture the attention of the Mathematical Literacy learners. These resources were brought to school by the learners. Teacher A largely kept to the planned lesson when teaching the lesson, but she could not finish the planned lesson in the allocated lesson time.

5.1.8 Questionnaire 2 (October 2007) after the lesson presentation

Teacher A completed Questionnaire 2 (October 2007) after the lesson presentation in a rush and it was not fully answered. However, the following points were made:

She explained the nature and purpose of Mathematical Literacy and the relationship between context and content:

> (Mathematical Literacy) has to do with real-life situation where one has to relate context to content. Context does help (the) learner to understand better and with that they are eager and it's easy for them to catch up with content. They (context and content) interact. With context one understands content better. Context is good but the content I think is too abstract for learners not doing science.

She described the difference between mathematics and Mathematical Literacy:

> Maths is abstract content. Maths Literacy has to do with context. Maths Literacy applies the things done in everyday lives. It links maths with other learning areas like science, geography, life sciences, etc.

She described her feeling about teaching the smokers' data:

> It's good. Learners are to be made conscious about the dangers of smoking. After learning that they can even educate their community and these can help to reduce the rate of smoking.

She said that her teaching of Mathematical Literacy had changed from February 2007 until September 2007 since:

It's better than before because theory and the ACE modules done (2007) did contribute.

5.1.9 **Interview (May 2008)**

In the interview (May 2008), Teacher A described the way she viewed Mathematical Literacy. A is Teacher A and J is the interviewer.

> A: Before that I thought it (Mathematical Literacy) is more related to the outside world. But now it is more content. Learners must know the content and then relate to the outside world. I thought it is more context than content (in the beginning), but you must have content, you must have context.

Teacher A's view on the relationship between context and content and the role of context were then explained further:

> J: When asked in the Questionnaire after your video lesson in October 2007 what you thought about the relationship between content and context, you stated: 'They interact. With context one understands content better. Context helps learner to understand better and with that they are eager and it's easy for them to catch up with content.' How might we understand this?
>
> A: You show them the context and then relate it to the content. And in that way teaching them things they experience everyday in their life and then, and lead that to content. Then they become more interested.

When asked about her lesson introduction, Teacher A revealed her view of the practice of smoking and her role as teacher:

> J: In Portfolio 1 (20 February), you started your lesson with the following statement:
>
> 'Smoking has been a norm and has been/is being practiced in our society. It's everywhere (used in all forms of media e.g. magazines, TV) hence creating the attitude amongst people of 'it's okay to smoke' and 'he is smoking, why can't I? Smoking hazards are not widely promoted as smoking in general is portrayed in advertisements or in our daily lives.' What do you mean with the above statement?
>
> A: People just smoke everywhere. Others will smoke before young ones. And children will see it as if it is ok to smoke. My father smokes then I can smoke. And also if we don't teach the kids the dangers of smoking, then they would see it worthwhile to smoke because no one is warning them. Advertisement. They will advertise it as if it's good. They will portray it as good. They advertise it all over. They portray it on big buildings on the road they advertise it. So, if they see that it is as it is promoted.
>
> J: And your role as a teacher? Do you think you should try and engage with it?
>
> A: Yes. I do think so.
>
> J: How?
>
> A: I should as a teacher. I have a big big role. I must indicate to them, I must show them the dangers of smoking. Whereby, if they know what it contains, the contents, what makes up that cigarette, the contents and know. If I indicate to them strongly, tell them the disadvantages of smoking, they will learn.

J: Will you then also tell them the advantages?

A: Advantages? (She laughs) As for me I don't know any advantages of smoking. I just heard that some they smoke to relieve stress, but I will show them the disadvantages of smoking.

This conversation opened up the values dimension which seemed to shift away from the initial objective view she had when planning the smokers' data lesson in Portfolio 1 (20 February 2007). Teacher A also commented on other topics that might present a moral or ethical stance:

J: Have you taught other contexts similar to the smoking task where you have taken a personal stance on the issue?

A: For example shopping. So when they go shopping, don't just buy. Budget. Budget for what you need most. So when you are budgeting, you know what you are going to buy. Don't just go for shopping, buy anything. At the end of the day you don't have that money. So budget.

J: Have you shared this with your class?

A: Yes.

J: Do you then think it is important to do so?

A: What a student said to me after I taught that on shopping and budgeting; she actually did that with her mum. And when paying for example you just pay, they give you change. So you must read your receipt, check whether the money, check what you got, is fine.

J: Do you think it is important to do that?

A: Yes.

It might be noted that, on reflection, I, as ACE Mathematical Literacy course assessor, may have influenced Teacher A to want to present herself as a 'good student'. This is particularly evident in the formal written ACE assessment tasks namely Portfolio 1 (20 February 2007), Portfolio 3 (13 March 2007), Assignment 1 (10 April 2007) and Assignment 2 (11 September 2007). In the next sections an overview and analysis of Teacher A's case study is discussed in detail.

5.2 Overview of Teacher A's story

Teacher A appeared to see Mathematical Literacy as mathematical life skills that a learner might need when s/he leaves school and will need to behave as an adult. When reflecting on the purpose of Mathematical Literacy she often deferred to curriculum speak and quoted sections drawn directly from course readings. This sense of academic awareness and learning which she gained regarding meaning, appeared to be reflected prominently in her identity as a student of the ACE Mathematical Literacy course. She showed that she had certainly read course texts and showed this in the assessment tasks that she submitted as part of the ACE Mathematical Literacy course. Teacher A appeared to largely 're-voice' the course literature relying heavily on restating the documents. However, she also appeared to have developed the learning component of meaning over time. She

initially had a largely contextual view with respect to the teaching of Mathematical Literacy. She described the relationship between mathematical content and context as integrated when she stated: 'Mathematical Literacy is inseparable from context, contents develops from context' (Portfolio 3, 13 March 2007). The description of the relationship between context and content later focused more on the mathematics when she stated: 'When teaching Mathematical Literacy is when you involve maths acting in the world where appropriate skills are used in different contexts' (Assignment 1, 10 April 2007).

Teacher A's planning and teaching practice showed that whilst she worked within both the context and the mathematics, she did not generally integrate the two components. The assessment tasks that the teacher prepared for the class showed that she engaged with both the contextual data and the mathematics, but kept the components mainly separate. In the data on lesson planning, assessment and teaching practice she initially led the learners to explore the general smoking context, had extended discussions about the context and engaged with the context. Then she did mathematical activities that used the contextual data as a vehicle for the mathematics (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007), without engagement and integration with the context. In her planning and snapshot of Mathematical Literacy teaching practice she largely worked in the Context driven agenda, followed by the Mainly content driven agenda (Graven and Venkat, 2007).

Teacher A indicated that the ACE Mathematical Literacy course had changed her understanding of the nature and teaching of Mathematical Literacy. She stated in the interview (September 2007) that her teaching of Mathematical Literacy had changed from February 2007 until September 2007 and was better than before. It might therefore be noted that Teacher A saw a link between her developing meaning with respect to the Mathematical Literacy curriculum and her own teaching practice.

The issue of ethical and moral values emerged strongly in the data collected for Teacher A. Whilst she appeared to be objective with respect to the practice of smoking in her lesson planning, her comments in the informal questionnaires, interview and teaching practice suggested the intention to influence learners clearly not to smoke.

5.3 Analysis of Teacher A' story

The analysis below probes the detail of the issues raised here. For Teacher A, these issues could be categorized according to the following sub-categories within the Wenger (1998) meaning/practice headings:

1 Meaning of Mathematical literacy

- Scholarly understanding of the nature and purpose of Mathematical Literacy
- Sharing of her own voice
- The link between Mathematical Literacy and mathematics

- The relationship between mathematical content and context

2 Mathematical Literacy teaching practice

- Analysis of questions set by Teacher A
- Analysis of the mathematics in Teacher A's snapshot of classroom practice
- Evidence of pedagogical support and scaffolding
- Mathematical Literacy and abstract mathematics
- The relationship between mathematical content and context
- Ethical and moral values

5.3.1 Meaning of Mathematical Literacy

The section on meaning relates to aspects of Teacher A's understanding of the nature and purpose of Mathematical Literacy and the way she sees the relationship between mathematical content and context.

5.3.1.1 Scholarly understanding of the nature and purpose of Mathematical Literacy

Teacher A's idea of the nature and purpose of Mathematical Literacy developed over time whilst attending the ACE course. She relied heavily on referencing the curriculum documents in the written tasks (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007). Initially (Portfolio 1, 20 February 2007) it might be noted that there is heavy referencing of only the NCS for Mathematical Literacy (DoE, 2003a) in the written assignments, but later on (Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007) she refers to other curriculum documents (DoE, 2005, p7) and course readings, in particular Steen (2001) and Pugalee (1999).

She relied on the NCS for Mathematical Literacy (DoE, 2003a, p9) when she described Mathematical Literacy as a learning area which 'teaches learners to cope with the outside world. It prepares and helps learners to deal with problems relating to real-life situations' (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007). Teacher A viewed Mathematical Literacy as a subject that prepared learners for life and for dealing with the world beyond school. She stated further that 'Mathematical Literacy …will ensure the development of critical thinkers who can take their place with confidence in modern society and ensure that South Africa plays a meaningful role on the global stage' (Portfolio 1, 20 February 2007).

In Portfolio 1 (20 February 2007) and Assignment 1 (10 April 2007) Teacher A described the purpose of Mathematical Literacy as development of 'a self-managing person, a contributing worker and a participating citizen'. This description of the purpose of Mathematical Literacy is very similar to the curriculum documents (DoE, 2003a, p 10 and p 43; DoE, 2005, p7).

In March 2007 (Portfolio 3) it appeared as if Teacher A consulted other readings, e.g. Steen (2001) and Pugalee (1999) to broaden her reading knowledge of Mathematical Literacy. She described Mathematical Literacy in a quote that shows heavy referencing from the NCS for Mathematical Literacy (DoE, 2003a) and Steen (2001):

> (Mathematical Literacy is) a habit of mind and an approach to problems that employs and enhances both statistics and mathematics. For people to function effectively in today's world, Mathematical Literacy is as essential as verbal literacy. It involves real data and procedures which are not prescribed. It is integral to all subjects i.e. it is flexible and can be used in different contexts, e.g. biology, history, geography, arts and economics. Mathematical Literacy empowers people by giving them tools to think for themselves, to ask intelligent questions of experts and to confront authority confidently.

Furthermore, in the same written assignment (Portfolio 3, 13 March 2007), she quoted the NCS for Mathematical Literacy (DoE, 2003a) and Pugalee (1999) in stating:

> Mathematical Literacy gives learners full access to the school curriculum and to participate fully in the adult world. Mathematical Literacy ensures the development of critical thinkers who can take their place with confidence. Our workforce needs citizens who can adapt to new technologies, identifying problems and communicating their findings using symbols, graphs, tables, pictures and words.

In Portfolio 3 (13 March 2007) and Assignment 1 (10 April 2007) Teacher A described the nature of Mathematical Literacy similar to Steen (2001):

> Mathematical Literacy is inseparable from context; (mathematical) content develops from context. It is driven by issues that are important to people in their lives and work.

Teacher A connected Mathematical Literacy to mathematics by quoting Steen (2001) when she stated 'when teaching Mathematical Literacy is when you involve maths acting in the world where appropriate skills are used in different contexts' (Assignment 1, 10 April 2007).

Overall, Teacher A restated the course readings almost word for word and appeared to be unable or unwilling to voice in her own words when answering the formal assignments that were part of the assessment of the ACE Mathematical Literacy course. This suggested a desire to show good 'scholarly' understanding of the subject as a student teacher on the ACE Mathematical Literacy course, a desire to portray herself as a 'good student'. This picture of a 'good student' does not necessarily indicate that she had assimilated and accommodated the new knowledge obtained in the curriculum documents and course readings; hence it does not necessarily reflect her own understanding (Wenger, 1998) of the nature and purpose of Mathematical Literacy. Teacher A preferred to regurgitate the curriculum documents and other course readings. In the next section occasional sharing of her own voice is pointed out.

5.3.1.2 **Sharing of her own voice**

Teacher A's tendency was to defer to the voice of a range of course texts with little evidence of the development of an own voice within tasks, questionnaires and the interview. Overall, this tends to indicate a possible lack of ownership of the concept of Mathematical Literacy (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007). Teacher A stated that learners have a need to be taught how to deal with real-life adult situations which they might encounter. Her example of such situations related to financial matters and learners' need to develop the skills to deal with these money matters:

> Mathematical Literacy deals with the kind of mathematics that learners might need to use when they leave school and get a job, for example, they will learn about how to use money or how to control money, which is an important skill for anyone to have.
>
> (Portfolio 1, 20 February 2007)

In Assignment 1 (10 April 2007) Teacher A argued that in Mathematical Literacy 'learners … use numbers … to do calculations and monitoring the financial aspects of personal and business issues, … Mathematical Literacy can help to start up a tourist company.' Hence it seems that she thought that she claimed that Mathematical Literacy deals with the kind of mathematics that learners might need as adults in the workplace, emphasizing the use of mathematics in financial management.

In the Questionnaire 1 (20 February 2007), Teacher A stated 'in maths literacy you would deal with stats of number of people who smokes and can be represented in a table form, graphs and be interpreted'. She emphasized that dealing with statistics is part of Mathematical Literacy. She suggested that standard mathematical representations of the statistical data which are common in everyday life, in particular tables and graphs, could be included as a feature of Mathematical Literacy. She also mentioned the word 'interpreted' after 'represented'. This suggested a view that 'something' needed to follow mathematical data representation, although she did not explain what this interpretation could consist of (Steen, 2001, p8). The interpretation might include an explanation of the trend that might be visible in the presented data, or perhaps predictions (interpolations or extrapolations) for the given data set. This statement might indicate that she saw Mathematical Literacy as mathematics set within a context where the context needed to be 'interpreted', hence indicating a link between content and context.

5.3.1.3 **The link between Mathematical Literacy and mathematics**

Teacher A quoted Steen (2001) as follows: 'When teaching Mathematical Literacy is when you involve maths acting in the world where appropriate skills are used in different contexts.' She described Mathematical Literacy teaching as the teaching of mathematics within a context.

Furthermore, Teacher A indicated strong reference to Steen (2001) in describing mathematics as abstract when she stated that in 'teaching maths there is a disconnection from meaningful context

which results in an absence of common number sense; it cannot be used in different contexts' (Assignment 1, 10 April 2007), and mathematics 'involves simplified numbers and straight forward procedures but requires sophisticated abstract concepts. Abstraction gives mathematics power' (Portfolio 3, 13 March 2007). In Questionnaire 2 (October 2007), Teacher A described maths as 'abstract content', therefore suggesting that she saw mathematics teaching as abstract and not as teaching within a real-life context.

In Questionnaire 2 (October 2007) she described Mathematical Literacy as she understood it then compared to what she thought in February 2007: 'Context is good but the content I think is too abstract for learners not doing science.' This view might indicate that she saw the learning outcomes for Mathematical Literacy as having a level of abstraction, therefore as decontextualised. The view that Mathematical Literacy in South Africa is mathematical, and hence has a level of abstraction, is shared by Christiansen who described the Mathematical Literacy curriculum as 'distinctly mathematical' (Christiansen, 2006, p10).

5.3.1.4 The relationship between mathematical content and context

Teacher A claimed that both context and content were necessary components of a Mathematical Literacy lesson when she stated 'Mathematical Literacy is inseparable from context' (Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007).

In the interview (May 2008), she made the following statement regarding the way she saw Mathematical Literacy early in the course in comparison to later: 'I thought it is more context than content, but you must have content, you must have context.' Teacher A thus clearly indicated that both content and context were key components in teaching Mathematical Literacy. This view is presented in chapter 3 and is shared by various researchers in the field Mathematical Literacy, including Steen (2001), Pugalee (1999), Skovsmose (1992), Venkatakrishnan and Graven (2006) and Graven and Venkat (2007).

Initially, Teacher A appeared to see Mathematical Literacy as life skills that a learner might need for post-school adulthood. Her view changed over time from a context orientation towards a notion that included both context and mathematical content.

She argued in Questionnaire 2 in October 2007: 'Context does help (the) learner to understand better and with that they are eager and it's easy for them to catch up with content.' She described the relationship between context and content as follows: 'They interact. With context one understands content better.' This indicated her own voice regarding the relationship between context and content, although she used the impersonal pronoun 'one' rather than 'I' or 'we'. It could be noted that Teacher A appeared to see the context as a way to catch the attention of learners and then to introduce the mathematics needed to understand or solve the contextual problem. This indicated a shift from her initial view where the focus was more on the context itself. She appeared to shift to a position of

saying that, if the context interested learners, they became more able to deal with the mathematics. Essentially, she stated that doing mathematics within a contextual framework supported the understanding of mathematics. This view is supported in some of the literature presented in chapter 3 (DoE, 2003a, p 43; Boaler, 1997 as taken up in Adler et al., 2000, p12).

In the next section I analyse Teacher A's Mathematical Literacy teaching practice.

5.3.2 Mathematical Literacy teaching practice

In the section on Mathematical Literacy teaching practice the reader is first presented with an analysis of the questions for the smoking context activity included in Portfolio 1 (20 February 2007) and the worksheet for Assignment 2 (11 September 2007) followed by the analysis of Teacher A's snapshot of Mathematical Literacy classroom practice (Lesson presentation, 2 October 2007). The analysis on the types and clarity, as well as the level of questions asked in the written assessment tasks emerged indirectly from the research question on how Mathematical Literacy is taught in the classroom. The written tasks were set for teaching with the same contextual data over a period of seven months and analysed using Venkat and Graven's spectrum of agendas (2007).

The question analysis related to how Teacher A saw the relationship between mathematical content and context in her lesson planning and lesson presentation (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007; Lesson presentation, 2 October 2007). I investigated Teacher A's style and the order of working with the components of context and content, the link between her teaching practice and the spectrum of agendas (Graven and Venkat, 2007), and the choice of context.

The analysis on ethical and moral values was not expected to be part of the research study initially, but their role emerged strongly from Teacher A's engagement with the smokers' data as a context for a Mathematical Literacy lesson.

5.3.2.1 Analysis of questions set by Teacher A

The analysis in this section is linked to Teacher A's assessment tasks for Mathematical Literacy. I categorized the questions for the smoking context in the activity in Portfolio 1 (20 February 2007) and the worksheet for Assignment 2 (11 September 2007) according to the following:

1. The nature of the question, specifically whether the question has a content or contextual orientation
2. The clarity of questions and whether the mathematics is purposeful in relation to the context
3. The cognitive level of questions according to the Mathematical Literacy taxonomy in the Subject Assessment Guidelines (DoE, 2008, p27-28) and Stein et al. (2000), where applicable

A summary of the types of questions and the cognitive level of questions in the activity in Portfolio 1 (20 February 2007) and worksheet in Assignment 2 (11 September 2007) is given in Table 12.

Comments on the clarity of the questions and whether the mathematics used led to insights about the context is pointed out in the detailed question analysis in the next section.

	Types of questions		**Cognitive level of questions**				
	Contextual questions	Mathematical questions where the context is in service of the mathematics	Knowing	Applying routine procedures in familiar contexts	Applying multistep procedures in a variety of contexts	Reasoning and reflecting questions	Low-level reflective questions
Portfolio 1	20%	80%	60%	20%	0%	0%	20%
Assign. 2	17%	83%	47%	40%	0%	0%	13%

Table 12 Teacher A: Types and cognitive level of questions

The categories for the types of questions emerged from a grounded analysis of the questions asked:

1. Contextual questions: Purely contextual questions with the focus on the investigation of the context. No reference is made to the mathematics; the mathematics is not in service of context.
2. Mathematical questions where the context is in service of the mathematics: Mathematical questions, but the questions use a contextual frame within which data is located and used to do the mathematics. The context is used as a vehicle within which mathematics is done. These questions are similar to traditional word problems.

The classification of the cognitive level of questions refers mainly to the taxonomy as indicated by the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008). The category of low-level reflective questions was included since some questions asked for reflection without reasoning mathematically to get to the answer. The reflection asked for was largely based on personal opinion and/or experience. For Portfolio 1 (20 February 2007) the percentage allocation per cognitive level was calculated with respect to the number of questions in the assessment task. The mark allocation percentage per taxonomy level for the worksheet (Assignment 2, 11 September 2007) was used to determine the percentage of questions on a specific cognitive level.

Overview of the nature of and clarity of questions

The discussed activity (Portfolio 1, 20 February 2007) and the worksheet (Assignment 2, 11 September 2007) appeared to have mainly mathematical questions where the context was in service of the mathematics. The mathematical questions used the context as a vehicle to do the mathematics. According to Table 12, Teacher A appeared to have a higher percentage of mathematical questions in

the worksheet for Assignment 2 (11 September 2007) compared to the activity earlier in the year in Portfolio 1 (20 February 2007).

Some mathematical questions could be described as 'very badly set' questions. This issue appeared to relate to a lack of clarity on language/ lack of precision. In some instances, this made the formula presented link badly to the question statement.

The mathematical and contextual questions were dealt with separately in the assessment tasks. The contextual questions did not require mathematical calculations to be answered; therefore the contextual questions did not require maths to be in service of the context. The contextual questions were sometimes linked to the ethical or moral values regarding the practice of smoking. This appeared to indicate a moral awareness or sensitivity (Tuana, 2007) with respect to the practice of smoking, but did not extend to 'ethical reasoning' in Tuana's terms.

Overview of the cognitive level of questions

All the questions in the activity (Portfolio 1, 20 February 2007) and worksheet (Assignment 2, 11 September 2007), might be classified as lower order questions. According to Table 12, Teacher A had a higher percentage of questions on the 'applying routine procedures in familiar contexts' level and a lower percentage of questions on the 'knowing' level in the worksheet (Assignment 2, 11 September 2007) compared to the activity earlier in the year (Portfolio 1, 20 February 2007). The percentage of 'low level reflective' questions was also lower in the second assessment task. No 'applying multistep procedures in a variety of contexts' (level 3) or 'reasoning and reflecting' questions (level 4) were included in either of the two tasks. Overall, the cognitive level of the questions for the second task (Assignment 2, 11 September 2007) was slightly higher than for the first task (Portfolio 1, 20 February 2007).

Paper 1 of the National Senior Certificate examination only contains level 1 and 2 questions; Paper 2 contains a small percentage of questions on level 2, but mainly focuses on level 3 and 4 questions (DoE, 2008, Venkat and Phungula, 2008). Since no level 3 and 4 questions were included, the questions for both tasks were not set according to the allocation per cognitive level for examination tasks as prescribed by the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008). The questions in the analysed tasks therefore only prepared learners for demands related to Paper 1 of the NSC examination (DoE, 2008).

The reflective questions in the activity and the worksheet (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007), were on a low cognitive level since they were not based on previous thinking levels of learning. Furthermore, these questions did not ask for mathematical reasoning or the use of mathematical solutions when working towards an answer. Therefore, these questions might be regarded as not suitable for Mathematical Literacy assessment tasks. However, Teacher A regarded

these questions as suitable for Mathematical Literacy tasks, and, more specifically, as questions on level 4 of the assessment taxonomy of the Subject Assessment Guidelines (DoE, 2008). This suggests a misreading of requirements for questions asking for reflection, with reflection sometimes based on personal views and experience.

Overall, the cognitive demand that the teacher expected from her class for the activity and the worksheet with respect to the mathematics was of a relatively low cognitive level. Brodie and Pournara (2005) suggest that the low level of cognitive demand might induce minor cognitive conflict within the class; which in turn, also would lead to few questions asked by the learners. The mathematical class discussion would have stayed within a simplistic cognitive demand framework.

A detailed question analysis on the nature, clarity and cognitive level of questions follows in the next two subsections.

The nature and clarity of questions

The detailed question analysis relates to the nature and the clarity of questions asked in relation to context and content for the two written activities.

Activity (Portfolio 1, 20 February 2007)

In Portfolio 1 (20 February 2007), the first part of the planned lesson focused on the context and the media's views on smoking. The second part of the lesson focused on the interpretation of the table and the activity which included ten questions.

In the activity in Table 8 on p60 questions 1, 2, 4, 5, 6, 7, 8 and 10 could be classified as mathematical questions where the context is in service of the mathematics. The argument for this classification is based on the following points:

1. The mathematical questions required identification (reading-off the table), comparison and simple mathematical calculations and presentations.
2. The questions appeared to be set with a mathematical purpose in mind.
3. No 'follow-up' questions were asked after reading-off from the table or doing calculations.
4. No contextual interpretation of calculations was required.

Question 8 asked learners to focus on the data for the African countries. The focus on the African continent perhaps represented an attempt at localisation, but this cannot be stated with certainty.

Question 10 could also be critiqued for the following reasons – which included a lack of 'need' for the mathematical content selected:

1. The difference in percentage rate could simply be read off from the given table. It was therefore not necessary to draw a graph to illustrate the difference in percentage rate

amongst smokers. The task to illustrate the data in a graph was therefore contextually superficial and suggested a largely mathematical purpose in mind.

2. The choice of five countries was left open to the learner. Follow-up interpretation might have been done by the learner; therefore the learner could link the answer to the question back to the context in order to unpack the context. However, relating the answer back to the smoking context was not asked in the activity.

Questions 3 and 9 were classified as contextual questions since learners were asked to reflect on the causes for the high smoking rate and ways in which the smoking rate amongst adults could be reduced. It appeared as if Teacher A required learners' answers to be based on their personal experiences of the habit of smoking. It is interesting to note here that no mathematical calculation was required in order to make context-related interpretation.

Worksheet for Assignment 2 (11 September 2007

The worksheet (Assignment 2, 11 September 2007, Table 11, p64) contained mostly mathematical questions where the context was in service of the mathematics.

Questions 1.1, 1.2 and 1.4 required the skill of reading-off the given table and arranging the data. Question 1.5 ambiguously asked for the calculation of the percentage of male smokers in Israel. The worksheet memorandum in Figure 3, p65, asked for percentage male smokers in Israel to be calculated using the following formula:

$$\%\ \text{male smokers in Israel} = \frac{\%\,men}{\%\,women + \%\,men}$$

This formula calculates the percentage of smokers in Israel who are male, but this is not clear in the question. The calculation of ratio in the worksheet in Table 11 introduced a new mathematics topic that was not included in the first activity in Portfolio 1 (20 February 2007). In question 2.1, Teacher A asked for the percentage men:women. This question was ambiguous since the two units could be interpreted as dissimilar, in particular the percentage (men) and the number of women. Lack of clarity and precision in her use of mathematical language was evident, although the example of Swedish men and women explained what she wanted. The worksheet memorandum in Figure 3, p65, confirmed that the question expected the comparison to be expressed as a ratio. The question might more clearly have been re-written as follows: Simplify the ratio: % men smokers: % women smokers. The example for Sweden was extremely simple: 19:19 is 1:1. According to the memorandum in Figure 3, p65, the answers (ratios) for the countries in question 2.1 were as follows:

1	South Africa	42:11	3,8:1
2	Argentina	46,8:34	1.4:1

3 Pakistan 36:9 4:1

Once again, the calculations for this question appeared to be done with a mathematical purpose in mind since no interpretation of answers was required.

When no calculator was used, the ratio calculations in question 2.1 were of varying cognitive demand. The cognitive demand for the calculation of the ratio for the given example (Sweden) was slightly lower than the calculations for the ratios of the countries asked in the question. The calculations of the ratio for all three countries were algorithmic and might be classified as a lower-level cognitive demand tasks (Stein et al., 2000). However, the procedure for Pakistan was the easiest of the three calculations, since no decimals numbers appeared in the question or the answer to the calculation. This task might have been placed first in the question. The calculation of the ratio for South Africa could have been placed second since the answer involved decimals. This might have made the calculation slightly more difficult since learners had to round off the answer, hence raising the cognitive demand of the task slightly. The question for Argentina involved decimal numbers and therefore the cognitive demand of the task was slightly higher than for Pakistan and South Africa. This question could have been placed last in question 2.1 in order to provide learners with a better scaffolding of the ratio concept.

However, if a calculator was used to do the calculations, the cognitive demand for the calculation of the different ratios would have been similar. If learners did the calculations mentally the cognitive demand would, on the whole, have been slightly higher and calculations might have taken longer to do. It might be noted that cognitive demand of a question relates to the way the answer is calculated.

Question 2.2 appeared not to be mathematically coherent. The question gave the percentage of smokers and asked learners to write down the tally and the frequency of smokers per country. According to the memorandum in Figure 3, p65, the question asked learners to show how the percentage should be recorded as a tally. Question 2.2 lacks purpose as a question since the tallying procedure has little purpose. The purpose of the question appeared to focus on how tallies can be recorded.

Question 3.1 asked for a bar graph of any six countries. The countries used in the worksheet could have been chosen randomly, therefore with no specific contextual purpose in mind, since the teacher required the learner to ‘choose any 6 countries’. This was not a question that gave a representation of the contextual data set, but purely assessed the mathematical skill of drawing a bar graph, not interpretation and unpacking of the given contextual data.

Question 3.2 was a question that the learners had to answer with no actual numbers of smokers (male or female), but only the rate of smoking percentages for 2002. The answer to the question appeared to be a guess. The mathematical and contextual purpose of this question seemed unclear and no interpretation of information was required.

The purpose of question 3.3 appeared to be purely mathematical and did not make sense in terms of the given context.

Question 4.1 appeared to be done with a mathematical purpose in mind; it did not contribute to a better understanding or solution to the smokers' context.

Questions 1.3 and 2.3 were contextual questions where the reasons for smoking and ways of reducing the number of smokers, based on personal opinion and experience, were asked. No mathematical calculations were required to answer the questions.

The cognitive level of questions

I did deeper analysis of the cognitive level of the questions in the assessment tasks since evidence suggested problems with meeting the prescribed ratio-allocation per cognitive level of question as intended by the Department of Education (DoE, 2008). Teachers needed to be aware of the classification of questions according to the four taxonomy levels (Table 3) in the Subject Assessment Guidelines (DoE, 2008, p27-28) in order to set appropriate assessment tasks in line with the curriculum documents.

The assessment grid for the taxonomy level of questions for the activity for Portfolio 1 (20 February 2007) in Table 8 on p60 and worksheet presented as part of Assignment 2 (11 September 2007) in Table 11 on p64 is provided in Table 13:

Taxonomy level	**Portfolio 1 questions**	**Assignment 2 questions** (45 marks)
Knowing	1, 2, 4, 5, 6, 8 (60%)	1.1, 1.2, 1.4, 1.5, 2.1.3, 2.2, 3.2, 3.3 (21 marks - 47%)
Apply routine procedures in familiar contexts	7, 10 (20%)	2.1.1, 2.1.2, 3.1, 3.3, 4.1 (18 marks – 40%)
Applying multistep procedures in a variety of contexts	(0%)	(0%)
Reasoning and reflecting	(0%)	(0%)
Low level reasoning	3, 9 (20%)	1.3, 2.3 (13%)

Table 13 Teacher A: Assessment grid (Activity, Portfolio 1; Assignment 2, 11 September 2007)

Activity for Portfolio 1 (20 February 2007)

Question 7 was classified as a 'apply routine procedures in familiar contexts' question since learners had to first substitute the percentages in the formula, and then do the calculation. Question 10 was classified as a 'apply routine procedures in familiar contexts' question since learners first had to translate the percentages to degrees before drawing the pie chart.

Questions 3 and 9 are reflective questions that ask the learners to make a judgement on the smoking context. These questions asked for a low level of cognitive demand and might therefore be classified as low-level reflective questions since it did not require mathematical calculations or a high degree of cognitive demand to be answered (Venkat et al., 2009). Learners could answer the reflective questions from general knowledge and life experience. These questions appeared to be inappropriate questions for a Mathematical Literacy assessment task.

Worksheet for Assignment 2 (11 September 2007)

The assessment grid (Table 13) shows that the mathematical questions were largely on a low cognitive level requiring knowing procedures (reading off and simple procedures) and applying routine procedures (DoE, 2008, p7). The contextual questions (Question 1.3 and 2.3) were reflective questions where the reasons for smoking and ways of reducing the number of smokers were asked. These questions asked for contextual reflection where no mathematical reasoning was required. Therefore, as reflective questions, they required a low level of cognitive demand (Venkat et al., 2009), and again were possibly inappropriate questions for a Mathematical Literacy assessment task.

5.3.2.2 Analysis of the mathematics in Teacher A's snapshot of classroom practice

The presence of mathematical errors in question statements and formulae led me to analyse the mathematical work Teacher A presented. Details of the lesson presentation (2 October 2007) can be found on p66. After Teacher A engaged with the context on smoking for approximately the first 20 minutes of the lesson, she asked the learners to calculate the total percentage of smokers in Albania and South Africa, although the total smokers' percentages were given in the table. The following formula was stated:

$$Total\ \% = \frac{\%\,men + \%\,women}{2}$$

This calculation assumes that the ratio of men to women in the dataset was equal, since the sum of male and female percentages was divided by two. This formula was not true for all the given values in the table, e.g. for Brazil. Teacher A made no attempt to check whether the calculation was true for all of the data in the table. The calculation appeared to be done with a mathematical purpose in mind, i.e. to check if learners could use the formula.

Thereafter Teacher A requested the learners to calculate the percentage female smokers in Brazil. As stated previously, the mathematical calculation shown in the memorandum does not match the statement clearly. Furthermore, the answer to the calculation (43%) did not match the percentage (29%) in the table, but neither Teacher A, nor her learners, further interrogated this answer. It might therefore be noted that the question and the answer to the question did not cohere well. The same statement for calculation formulas was repeated when she calculated the percentage of Brazilian men. This shows a lack of attention to what is being worked out, and what the answer to the calculation means in context.

Across questions, a mathematical purpose predominated and no follow-up interpretive contextual questions were asked.

The use of technology, in this instance the calculator, is described by Pugalee (1999) as one of the enablers of the mathematical processes that take place in the Mathematical Literacy classroom. The use of the calculator in this particular classroom did not add to the development of the mathematical processes since too few learners had calculators to work with. However, the calculator could have been used as an enabler during the Mathematical Literacy lesson if the technology was used to demonstrate to the learners the advantage of doing the calculations with a calculator instead of mentally. The advantages could have included better time management and more accurate calculations.

5.3.2.3 **Evidence of scaffolding**

In Assignment 2 (11 September 2007), in the lesson plan in Table 10, the teacher asked the learners to calculate the median, but she asked the learners to 'first rearrange the scores and then find the middle most score'. By instructing the learners to rearrange the scores, the Teacher A scaffolded the learners in the procedure of calculating the median.

5.3.2.4 **Mathematical Literacy and abstract mathematics**

Teacher A's Mathematical Literacy teaching practice showed that she largely worked within a contextual frame and then followed it with some mathematical calculations, but, as pointed out previously, the teacher did not connect the mathematical answers back to the context again. Therefore the calculations stayed abstract in relation to the context. This can be observed in Assignment 2 (11 September 2009) where the body of the lesson involved a contextual discussion followed by a separate mathematical discussion (Table 10). The mathematics, e.g. the calculation of the measures of central tendency and spread, did not relate to or unpack the context further; and it did not aid to better understand or solve a contextual problem. No attempt was made to ask how the context led to the framing of the question, or to ask what the answer told us about the context, hence the mathematics stayed abstract.

The Department of Education's objective of the teaching of Mathematical Literacy 'is to use situations or contexts to reveal the underlying mathematics while simultaneously using the mathematics to make sense of the situations or contexts' (DoE, 2006, p4). In other words the context should reveal the embedded mathematics, and further, the calculations need to feed back to the context to solve problems or unpack the contextual situation. In doing this the mathematics will not stay abstract, but will deepen understanding of the context (Graven and Venkat, 2007). Steen shares a more context-based view than the Department of Education when he states 'numeracy is often anchored in data derived from and attached to the empirical world' (Steen, 2001, p5). It might be noted that Steen sees the teaching of Mathematical Literacy as staying within the context, and pulling the relevant mathematics into the context to explain and unpack the context.

Teacher A's practice did not fit in with the Department of Education's or Steen's view since she kept the discussion of the context and the 'doing mathematics' separate; and the mathematics she did stayed abstract since it did not feed back into the context in order to deepen the understanding of the context.

In the next section Teacher A's teaching practice with respect to the relationship between context and mathematical content is discussed in more depth.

5.3.2.5 The relationship between mathematical content and context

In this section I investigate different aspects of Teacher A's teaching practice and the relationship between content and context.

The style of working with content and context

In Questionnaire 1 (20 February 2007), Teacher A shared her informal view about Mathematical Literacy when she stated that 'in Maths Literacy you would deal with stats of number of people who smokes and can be represented in a table form, graphs and be interpreted.' She stated the data should be represented and interpreted. This statement suggested that she saw Mathematical Literacy as mathematics set within a context where the context needed to be 'interpreted'. The interpretation included an explanation of the trend in the presented data or predictions for the given data set. The scenario of teaching could be described by doing maths with contextual data, and then interpreting the mathematical calculations within the context; hence indicating a connection between the content and the context.

In the planned lesson of Portfolio 1 (20 February 2007), the class discussion was contextual, but the planned learners' work was mathematical and largely procedural. Teacher A appeared to prefer to engage with the context first when teaching the lesson; thereafter she used the context to serve as a vehicle to do the mathematics. Teacher A extensively worked with the context in the introduction of the lesson. She did this by introducing the media's view on the practice of smoking and investigated the reasons why people smoke and how smoking might influence one's health. Thereafter the

mathematics was explored in the assessment task. The activities for the planned assessment task indicated that she kept the context and the mathematics separate and very little interplay was observable between the context and the mathematics. Most of the questions appeared to be chosen with a mathematical purpose in mind using the context as a vehicle to do the mathematics, for example the following questions in Table 8:

> Question 7: Calculate the average percentage of men and women smokers?
>
> Question 10: From the data given draw a pie/bar graph illustrating the difference in the percentage rate amongst smokers. Choose 5 countries.

No follow–up questions were included to link the answers to the mathematical questions back to the context, therefore there is no evidence of 'interpretation' of representations that she mentioned earlier in Questionnaire 1 (20 February 2007).

In Assignment 2 (11 September 2007), Teacher A submitted a lesson plan for the rate of smoking amongst adults data. The prior knowledge that the teacher expected from the learners in the planned lesson was set in context and the focus was on the different types of cigarettes, the effects of smoking, the profile of a smoker and the understanding of where one would encounter more smokers. A very low level of mathematical knowledge was assumed when Teacher A indicated prior knowledge of counting the numbers of cigarettes in each box. The prior knowledge focused on the context and the mathematical skills of number recognition and comparison. This knowledge was well below what is expected as mathematical prior-knowledge for grade 9. According to Adler et al. (2000, p5, 9), the mathematics might 'get lost' or become 'overshadowed by the theme' if the focus falls on the context. It is interesting to note that Teacher A did not indicate grade 9 mathematical topics, e.g. rate and ratio as prior knowledge for the lesson. On the other hand the lesson outcomes were mostly stated in mathematical terms as a set of skills that needed to be managed. The suggested lesson outcomes (in Table 9) were largely mathematical, but Teacher A referred to the 'draw and interpretation' of a frequency table and graphs as lesson outcomes. The outcome on interpretation again suggested that Teacher A planned to link the mathematical interpretation back to the context again.

The planned development of the lesson was explained under the headings of introduction, body of the lesson and conclusion in Table 10. The planned introduction of the lesson was done with a contextual purpose in mind and the teacher referred to different kinds of smoking substances and provoked a class discussion regarding the disadvantages of smoking and the number of people that smoked in the families of the learners. The contextual information was not explicitly linked to a mathematical discussion. The planned body of the lesson continued to focus on the context and the way smoking is portrayed in the media. The teacher referred to the table of data and points out specific information in the table without interpreting the data. Teacher A then sharply diverted the lesson away from the context that was focused on in the introduction, and brought in mathematical calculations. The

mathematics the teacher asked from the learners included the calculation of percentages, measures of central tendency, the range and the drawing of a bar graph. The answers to the mathematical calculations were not interpretively linked back to the smoking context; they did not solve problems within the context and failed to unpack the context further. In the conclusion of the lesson the teacher again focused on the smoking context and the view of the media on the practice of smoking.

As discussed in the previous section, the worksheet (in Table 11) for the planned lesson (Assignment 2, 11 September 2007) focused largely on mathematical learning, but included a few contextual questions. It appeared as if the context was, similar to the activity in Portfolio 1 (20 February 2007), used as a vehicle for doing the mathematics.

In the actual presentation of the lesson (2 October 2007), the teacher spent most of the lesson exploring and analysing the context before switching over to do the mathematics where the context was used as a vehicle for doing the mathematics. The answers to the mathematical calculations were not linked back to the context; hence the unpacking of the context and the doing of mathematics was therefore largely kept separate. She did not investigate whether the mathematical calculations made sense seen against the background of the context. The purpose of the exercise appeared to be 'to do some mathematics' and there appeared to be no contextual reasons why the calculations were done.

To summarise: Teacher A included both components of context and mathematical content in the two lesson plans and assessment tasks (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and the lesson presentation (2 October 2007) discussed above. The context and the mathematics were alternatively foregrounded and little integration was visible between the context and the mathematical content. The context appeared to be used as a vehicle to do the mathematics. Contrary to Teacher A's statement that Mathematical Literacy deals with mathematics and its interpretation in Questionnaire 1 (20 February 2007), she appeared to keep the contents and context separate across the planning (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and teaching (Lesson presentation, 2 October 2007) of the lesson. The contextual discussion focused mainly on the general context of smoking and moral issues with respect to the practice of smoking. The discussion did not emphasize the embedded mathematics and the answers to the mathematical calculations did not feed back into the context to further unpack the context.

The order of working with content and context

Teacher A did not give clarity on the order in which the components of context and content should be presented in the classroom. Throughout the sixteen months during which the research data was collected, Teacher A's view with respect to the order of presenting context and content did not settle down to one consistent opinion. She recognized the need for both content and context, but her comments suggest that she would sometimes work from decontextualised content into applications,

and other times from the context into the mathematics. Evidence is presented in the next two paragraphs.

Teacher A initially suggested that the context should first be chosen and then the mathematical content should be determined to understand and engage with the context. Evidence is found in Portfolio 3 (13 March 2007) when she stated 'content develops from context', in Assignment 1 (10 April 2007) when she stated that 'Mathematical Literacy … is maths acting in the world where appropriate skills are used in different contexts', and in the Interview (May 2008) when she said: 'you show them the context and then relate it to the content … things they experience everyday in their life .., and led that to content'. In her two lesson plans (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and observed teaching (Lesson presentation, 2 October 2007) the teacher largely engaged with the context first, and then did the mathematics.

However, there is also evidence that Teacher A suggested that the mathematical content should first be selected and taught, and the application of the mathematics learned should then be done within the context. Evidence of this view is evident in Questionnaire 2 (October 2007) when she stated 'one has to relate context to content', and in Interview (May 2008) when she said 'learners must know the content and then relate (it) to the outside world'. It might be noted that, as quoted in the previous paragraph, Teacher A seemed to change her opinion regarding the order of working with contents and context in the Mathematical Literacy classroom in the same interview (May 2008). This occurred in spite of the fact that all tasks presented in the course were embedded in contexts.

The relationship between content and context with respect to the spectrum of teaching agendas described by Graven and Venkat (2007).

I analysed the data within the pedagogical framework developed by Graven and Venkat (2007). As discussed in chapter 3 this framework presents four agendas that can be used as an analytical tool for analysing Mathematical Literacy teaching practice, in particular with respect to the relationship between context and mathematical content. The data in the story of Teacher A gave evidence of her perception of how she saw the relationship between context and content and in which teaching agenda (Graven and Venkat, 2007) she might possibly be placed.

As noted above, the lesson plans showed little interplay between the context and the content as described by the Subject Assessment Guidelines (DoE, 2008, p7). Teacher A's lessons could not easily fit into one of the driving agendas as described by Graven and Venkat (2007). I attempted to fit the contextual section of the lesson plans into the Context driven agenda and the mathematical section in the Mainly content driven agenda, but could not fit it into the frame. According to the spectrum of teaching agendas the Context driven agenda focuses on 'increased discussion of the contexts … and the mathematics embedded in them', thus the mathematics stands in service of the context. This was not the case with Teacher A's lesson plans, assessment tasks and lesson presentation. When Teacher

A engaged with the general context of smoking, the specific contextual data and the embedded mathematics were not unpacked. The contextual discussion did not lead to critical engagement with the embedded mathematics. On the mathematical side of the spectrum the driving agenda for the Mainly content driven agenda is portrayed as the agenda 'to learn maths and then to apply it to various contexts'. In this agenda the teaching focuses on 'mathematical learning and its use in applications', but Teacher A focused on the context and used it as a vehicle to do the mathematics. Furthermore the answers to the calculations did not link back to the contextual discussion; therefore, the mathematical learning did not become useful in the contextual application.

In summary, it can be concluded that the teacher worked with the context and the mathematical content, but kept the two components separate. She worked partially within the Context driven agenda (agenda 1) and the Mainly content driven agenda (agenda 3) described by Graven and Venkat (2007). The teacher did not move into the Content and context driven agenda (agenda 2) where the context is explored to deepen the mathematical understanding and mathematics is learned to deepen the understanding of the context.

The analysis suggests that the spectrum of Mathematical Literacy teaching agendas might need to be expanded to accommodate Teacher A's approach to teaching Mathematical Literacy. This might be done by developing another agenda and/or adapting an existing agenda. The new agenda could focus on the interrogation and engagement of the context without engaging with the embedded mathematics. The Mainly content driven agenda could possibly be adapted to accommodate the contextual scenario that is used as a vehicle within which the mathematics is located, in other words the 'context that locates the maths'. The answers to calculations in this agenda are not necessarily linked back to the context.

The choice of context

Julie (2006) states the choice of contexts for the teaching of Mathematical Literacy is a complex issue. Skovsmose (1998, as taken up in Julie, 2006), argues that 'learners are generally not interested in dealing with activities from their backgrounds and suggests that contexts focusing on the likely futures of learners should be foregrounded.

Teacher A claimed that teachers should choose contexts that are familiar and interesting to the learners. If the learners were interested in the context they would therefore engage with the mathematics. She shared her own opinion in Portfolio 3 (13 March 2007) as follows:

> It (Mathematical Literacy) is driven by issues that are important to people in their lives and work, therefore teachers should choose contexts that is meaningful to learners.

Teacher A was able to present and relate the general smoking context to the learners in a way that was interesting and meaningful to the learners.

Furthermore, in the interview (May 2008) she stated:

> You show them the context and then relate it to the content. And in that way teaching them things they experience everyday in their life and then, and lead that to content. Then they become more interested.

This view agrees with the view of Steen:

> To be effective, numeracy skills must be taught and learned in settings that are both meaningful and memorable. (Steen, 2001, p16)

However, it can be noted that Teacher A was not able to relate the context to the content in her lesson plans (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and lesson presentation (2 October 2007) since the context and the content did not meaningfully interconnect. She frequently referred back to her training and previous teaching experience as a life sciences teacher when engaging with the context, and within the smoking context data she focused strongly on the health hazards of smoking.

5.3.2.6 Ethical and moral values

An emergent feature in both her early lesson plan (Portfolio 1, 20 February 2007) and her later lesson plan (Assignment 2, 11 September 2007) and teaching (Lesson presentation, 2 October 2007) was an overtly personal stance regarding the practice of smoking. It appears as if she saw it as her responsibility to influence the learners to share her personal view of smoking and used the context largely as a vehicle to share her moral position. This might be seen as what she interpreted to be the role of a teacher and hence defined her perception of the meaning of Mathematical Literacy (DoE, 2003a, p2, 9; Tuana, 2007, p2).

Teacher A's opinion

Teacher A's personal stance regarding smoking was strongly reflected in Questionnaire 1 (20 February 2007), her lesson presentation (2 October 2007), Questionnaire 2 (October 2007) and the interview (May 2008), but largely not in the written lesson plans (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) for the smokers' data context. She shared her opinion with respect to the practice of smoking, but indicated no attempt to interrogate the data further. Teacher A's opinion is shared in the quotes below:

In Questionnaire 2 completed after the lesson presented on 2 October 2007, Teacher A describes her feeling about teaching the smokers' data:

> It's good. Learners are to be made conscious about the dangers of smoking. After learning that they may even educate their community and these can help to reduce the rate of smoking.

Teacher A appeared to see the purpose of this activity to be mainly related to life education, rather than mathematical education.

Teacher A personalised the practice of smoking by linking it to a learner in the class (Lesson presentation, 2 October 2007). It could be interpreted that she anticipated that her teaching of the lesson might then have a stronger impact on the learners (and the community) by making them aware of the disadvantages of smoking. This view in informal Questionnaire 2 (2 October 2007) suggested that the warning sent out to the learners regarding the practice of smoking was part of her lesson plan, although not written down formally in the plan.

In the informal Questionnaire 1 (20 February 2007), she took a strong anti-smoking line by sharing her personal thoughts on the smokers' data task as seen from a biological viewpoint. She claimed:

> I think a high percentage of people around the world are smoking, which in the long run the society can get diseases due to smoking, and people will die in large numbers, e.g. from liver cancer.

Teacher A repeated the anti-smoking view when she shared a strong personal opinion with the class regarding the practice of smoking in the lesson (2 October 2007):

> If you are smoking for your entire life it can cause health problems like cancer....and if they (lungs) are mostly affected they will collapse. You can even die.

In the interview (May 2008), Teacher A stated that as a teacher she felt obliged to inform the learners of the disadvantages and the dangers of smoking. The teacher appeared to see it as her pedagogic responsibility to influence the learners (Tuana, 2007, p2). She admitted that she would not promote the practice of smoking since she personally did not see any advantage in smoking. She said:

> I have a big big role. I must indicate to them, I must show them the dangers of smoking… If I indicate to them strongly, tell them the disadvantages of smoking, they will learn. Advantages? (She laughs) As for me I don't know any advantages of smoking. I just heard that some they smoke to relieve stress, but I will show them the disadvantages of smoking.

In the ACE based lesson plan tasks (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) Teacher A introduced the lesson by discussing the context extensively by describing the practice of smoking with moral lenses. The teacher retained a relative objective viewpoint and suggested that she planned to give learners access to pro- and anti-smoking perspectives and appeared to share a largely non-judgemental position with respect to the practice of smoking. In Assignment 2 (11 September 2007), the teacher planned to show learners the different types of tobacco's and allowed for a class discussion on 'whether smoking is good or bad'. She stated the reasons for smoking as relieving stress and for fun and peer pressure; on the other hand she warned that smoking could cause lung cancer. She shared her personal opinion, but appeared to give the learners the opportunity to judge for themselves whether the habit of smoking is feasible or not. The notion of individual choice appeared to be respected.

The choice an individual makes links to ethics sensitivity and ethical reasoning (Tuana, 2007, p1). As discussed previously ethics sensitivity implies a decision whether or not a certain situation requires an ethical lens. Teacher A showed evidence of ethical sensitivity (Tuana, 2007) with respect to the general smoking context in her lesson planning, assessment tasks (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and lesson presentation (2 October 2007). Ethical reasoning (Tuana, 2007) links to the assessment of the situation against the background of community beliefs, values and practices. There is no evidence in the lesson plans, tasks or teaching of critical reasoning based on both facts and values. Furthermore, moral imagination was partially present when Teacher A shared the image of the effects of smoking on a learner as a smoker twenty years later since the image was based on emotions and not on the facts of the given situation. In the next two sections I give evidence of Teacher A's different stances with respect to smoking in her lesson planning (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and teaching practice (Lesson presentation, 2 October 2007).

Evidence of an objective stance regarding the practice of smoking

In Portfolio 1 (20 February 2007), Teacher A focused on opening up moral issues with respect to the practice of smoking and shared a moral values perspective (Tuana, 2007) with the learners. She stated:

> Smoking has been a norm and has been/is being practised in our society. It's everywhere (used in all forms of media e.g. magazines, TV) hence creating the attitude amongst people of 'it's okay to smoke' and 'he is smoking, why can't I'. Smoking hazards are not widely promoted as smoking in general is portrayed in advertisements or in our daily lives.
>
> (Portfolio 1, 20 February 2007)

In Portfolio 1 (20 February 2007) she included two figures that 'show people smoking everywhere, anytime' and in Assignment 2 (11 September 2007) she included a picture that showed that one might smoke to relieve stress.

In the lesson presentation (2 October 2007), Teacher A appeared to be open-minded and indifferent towards the habit of smoking since she allowed the learners to bring illegal substances e.g. dagga and Taiwan to the classroom, and even created an opportunity for the class to discuss how the substances should be used. It might be observed that these drugs did not seem to be unknown to the learners and seemed to be freely available in their community. She indicated the reasons for smoking, but warned the learners of possible health problems.

Evidence of a subjective stance regarding the practice of smoking

On the other hand, Teacher A demonstrated a subjective stance in Portfolio 1 (20 February 2007) and Assignment 2 (11 September 2007) with respect to the practice of smoking when she included a warning in a magazine that said:

> Smokers are 70% more likely, on average, to need root canal than those who never smoked.

She also included an article on the success of wearing nicotine patches to quit smoking. The article included a warning by the Heart and Stroke Foundation regarding tobacco smoke (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007).

In the lesson planning in Assignment 2 (11 September 2007) and the lesson presentation (2 October 2007), Teacher A asked the learners to 'explain disadvantages of smoking, its effects on peoples' lives'. In the body of the planned lesson she included the following quote from the introduction to the rate of smoking data:

> According to research of the World Health Organisation it says that tobacco is the only product that will cause death of one in every two people who uses it.

She continued to convey an anti-smoking opinion when she asked the learners in question 2.3 in the worksheet (Assignment 2, 11 September 2007) for the planned lesson: 'Think of two ways in which the smoking rate amongst adults can be reduced. Furthermore, the teacher reflected her own value stance regarding the smoking practice (Assignment 2, 11 September 2007) when she concluded the lesson plan with 'but at the end of the day it's not healthy for the body because of its contents'.

In the lesson presentation (2 October 2007), Teacher A focused the class discussion on the disadvantages of smoking, accentuating illnesses that might be caused by the smoking. The teacher used the image of a learner who did smoke, Jack, age 18, and asked learners to imagine what effect the habit of smoking could have on him over time. In selecting a person that is familiar to the learners she could make the effect of the habit more real and personal. However, the description could partially be described as moral imagination according to Tuana (2007), since moral imagination is the result of a 'blend of affective and rational processes' (Tuana, 2007, p5), therefore based on reasoning and emotions. The action of selecting a certain learner and drafting an image of a sick person suffering from lung cancer and Tuberculosis could involve emotions and the learner might feel anxious or uncomfortable. This might raise an ethical issue in itself.

To summarise: Teacher A initially seemed to be objective with respect to the practice of smoking in her lesson planning (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007), but her comments in the informal questionnaires and interview (Questionnaire 1, 20 February 2007; Questionnaire 2, October 2007; Interview, May 2008) and teaching practice (Lesson presentation, 2 October 2007) suggested that she aimed at influencing learners overtly not to smoke. She shared an ethical sensitive (Tuana, 2007) view with regards to the practice of smoking, but did not reason the given data within class discussions. This led to a moral opinion where she stated that she did not agree with the practice since it is harmful to one's health.

In the questionnaire (May 2008), I requested Teacher A to state other contexts, if any, where she might reveal a value or a moral opinion in the Mathematical Literacy classroom. Teacher A stated that she had taught other contexts where she took a personal stance, e.g. the context of shopping and budgets. She had shared her personal view on the importance of budgeting with the class. She claimed that sharing her value perspective impacted on one of the class learners in a positive way since the learner and her family said that they were now more sensitive to how money is spent.

5.4 Teacher B's story

Similar to Teacher A, Teacher B's story is told chronologically according to the empirical data collected with the data collection instruments.

5.4.1 ACE Teacher Profile form

Teacher B was a teacher for 15 years teaching mainly geography and life sciences. He had no experience of teaching mathematics, but only revealed this fact in September 2007. Most of the years spent teaching he was involved with the FET band (14 years with grade 10, 5 years with grade 11 and 5 years with grade 12). He spent 13 years teaching grade 9 learners. He had taught Mathematical Literacy to grade 10 learners for two years (2006 and 2007). He had a BA (Ed) with geography as major subject; his highest qualification in mathematics was grade 12. He stated that he had prior access to the NCS for Mathematical Literacy (DoE, 2003a), but it is unknown whether he had engaged with the policy document before attending the ACE Mathematical Literacy course.

5.4.2 Portfolio 1 (20 February 2007)

In the second session of the ACE Mathematical Literacy course Teacher B described Mathematical Literacy as follows (Portfolio 1, 20 February 2007):

> According to wikibooks, Mathematical Literacy is defined as a subject which provides learners with an awareness and understanding of the role that mathematics plays in the modern world. It enables learners to develop the ability and confidence to think numerically and spatially in order to interpret and critically analyse everyday situations and solve problems. It is the subject which will make the future citizens of the country to be numerate consumers of mathematics. It enables learners to engage with real life problems. Learners will be able to make sense of information communicated in tables, graphs, diagrams and texts. Learners will develop basic mathematical skills in critically analysing situations and creatively solving everyday problems such as hire-purchases, mortgage bonds and investments. Learners develop the ability to read maps, follow timetables, estimate and calculate areas and volumes and understand house plans and sewing patterns.

In addition to his thoughts on Mathematical Literacy, Teacher B submitted written ideas for teaching the data on the rate of smoking amongst adults (Table 5) for Portfolio 1 (20 February 2007). He stated that copies of the table that showed smokers' percentages had to be distributed amongst learners in the classroom. He shared the following teaching ideas in Table 14:

Teaching ideas on the data on the rate of smoking amongst adults	
1	Learners will be requested to identify all sampled countries on the political map of the world.
2	Countries will be ranked from the one with the highest percent of smokers to the one with the lowest percent of smokers. (The aim is to make easier for the calculation of the median).
3	Learners will further be requested to rank countries in terms of the highest and the lowest female and male percentages of smokers. After this has been done, learners will be shown how to calculate the arithmetic mean, median and the mode.
4	As soon as they show an understanding, they will be required to calculate the mean, median and mode of both the female and male percentages of smokers
5	The percentage of the African men smokers will be compared with the average of European men smokers. This average will be compared with the average of European men smokers. Learners will be expected to draw conclusions based on the comparisons of the two.
6	Learners will be requested to identify the top ten countries of high smokers and represent them on a bar graph. A bar graph of the six African countries with the percentage of smokers will also be drawn.
7	Woman smokers from six African countries will be identified and a pie diagram that represents their percentages will be drawn. Learners will be expected to draw their conclusions based on what they see on the pie diagram.
8	Learners will be required to identify the top ten countries where the tobacco companies are making huge profits from the sales of cigarettes and where they make less profit.
9	To conclude, learners will collect data about how countries of the world are fighting the war against smoking.

Table 14 Teacher B: Teaching ideas (Portfolio 1)

Teacher B indicated that the resources to be used when presenting the lesson included the newspaper article which was handed out as part of Portfolio 1 (20 February 2007), calculators and a political map of the world.

5.4.3 Questionnaire 1 (20 February 2007)

Teacher B reflected his personal take on the task on the design of a Mathematical Literacy lesson using the smokers' data in the informal Questionnaire 1 (20 February 2007**).** The questionnaire was completed during the second ACE Mathematical Literacy session. He said the following with respect to the Mathematical Literacy smokers' task:

> I felt confused and did not know where to start. It fitted in well (with my idea of Mathematical Literacy) because information in this world is communicated through tables and graphs. Mathematical Literacy enables learners to be able to understand the manner in which information is communicated.

He referred to personalised learning experience in teaching the task as follows:

> It was a bit confusing because I did not know whether I should start with the emphasis on the graphs or should I concentrate on the median, mean and mode but at the end I tackled both. I integrated it with geography.

When he referred to his teaching experience he stated:

> It was a bit difficult more especially when teaching learners who can't draw graphs with correct scales. You deviate a lot on the development of graphs. It becomes easier when learners master the graphs.

5.4.4 **Portfolio 3 (13 March 2007)**

In Portfolio 3 (13 March 2007) Teacher B mainly described Mathematical Literacy in terms of the definition included in the NCS for Mathematical Literacy (DoE, 2003a), but added:

> It (Mathematical Literacy) gives learners confidence in dealing with technology (computers and calculators), handling and manipulation of data, and solving problems. It also gives learners tools to use before making informed decisions. Learners are able to think critically and confidently. The subject may include reconciliation of bank statements, analysing data to support or oppose views, estimation, using statistics to decide and building logical conclusions and understanding different risks involved in investments. All of these concepts and contents are not being treated in mathematics.

He described the purpose of Mathematical Literacy as follows:

> Mathematical Literacy is offered as an alternative to mathematics. The purpose is to address the declining number of learners who are consumers of mathematics and also to offer learners who are interested to do courses at higher levels which do not have significant mathematical content an opportunity to do mathematics at school level. People who do law and other social sciences, come across mathematical inclined experiences in their studies and real life experiences and therefore Mathematical Literacy will come handy for them. It is also aimed at developing higher order thinking amongst learners because it is understood that the use of calculators encourages the development of higher order thinking.

When asked to describe the difference between maths and Mathematical Literacy he mentioned the following difference:

> Mathematical Literacy is a subject which is context based and uses mathematics content to solve the context. In mathematics the procedures and methods are the things that are mainly emphasized, for example, learners are taught to calculate the interest using formulae $A=P(1+i)^n$ following step by step. When in Mathematical Literacy the simple formulae can be used so that the learner can make a decision in a given context.

He emphasized a more mathematically-orientated view regarding the nature of Mathematical Literacy with reference to technology:

> Technology helps learners to investigate mathematical ideas and finding solutions to mathematical problems.

5.4.5 Assignment 1 (10 April 2007)

Teacher B revealed shifts beyond the NCS for Mathematical Literacy (DoE, 2003a) regarding the nature and purpose of Mathematical Literacy, quoting Steen (2001) in Assignment 1 (10 April 2007):

> It involves real data and procedures which are not prescribed and requires elementary maths. Mathematical knowledge gained at grade 9 is regarded as significant for the learner to apply in Mathematical Literacy.

Furthermore, when Teacher B was asked to point out the difference between 'school maths' and Mathematical Literacy, he submitted an example of a maths and a Mathematical Literacy question as part of a formal assessment task for the ACE Mathematical Literacy course. The Mathematical Literacy question was taken straight from the National Senior Certificate Mathematical Literacy grade 10 Paper 2 set by the Department of Education (DoE, 2006).

5.4.6 Assignment 2 (11 September 2007)

Teacher B's proposed lesson outcomes, prior knowledge linked to the lesson outcomes and assessment tools for the planned lesson for Assignment 2 (11 September 2007), are given in Table 15 below:

Lesson outcomes	**Prior knowledge**	**Assessment tools**
Learners will be able to write ratio to percentages. Learners will be able to draw graphs, pie charts etc from data in tables Learners will be able to use graphs and tables to make comparisons and draw conclusions.	Ratio, percentages, angles, plotting of graphs.	Worksheet

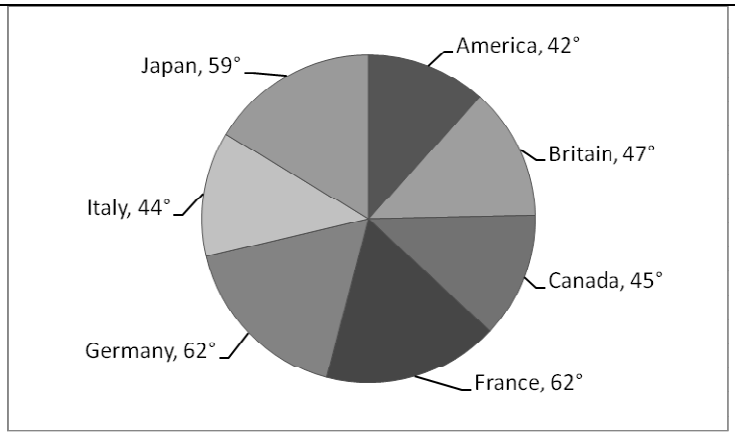
Table 15 Teacher B: Lesson outcomes, etc (Assignment 2)

Teacher B suggested the following written development of the lesson for Assignment 2 (11 September 2007) provided in Table 16:

Lesson plan		
	What the teacher will do	What the learners will do
Introduction	Explain ratio 1:2 and what does it mean. Write percentage as a ratio. Show the learners how to use protractor to measure angles. Plot coordinates on the graph.	Learners will be required to give their own understanding about ratio, percentages, measuring of angles and plotting of graphs.
Body of the lesson	The percent of smokers in a particular country will be written as ratio e.g. 39% $\rightarrow$39:100 To draw a pie chart- total percentage of smokers to be expressed as angles so that sectors can be cut e.g. $\frac{39}{100} \text{x } \frac{360}{1} = 140.4°$ On the circle the $140°$ will be measured. Total percentages of smokers will be plotted. A compound bar graph will be used to plot graph of both men and female smokers. Bar graph of the seven richest countries and the African countries can also be drawn. Learners will be shown the existing differences in terms of smokers. African countries will be plotted against each other and be analysed. Conclusion can also be drawn.	Require to write total percentage of smokers as ratios. Total percentages of smokers converted to degrees. Learners draw their own table that shows frequencies converted into degrees. Learners identify countries selected on the world map. Give seven richest countries of the world. Give their analysis and conclusions.
Conclusion	South Africa and Nigeria will be chosen and brief history of the two countries given: i.e. religion, society, economy, population, etc.	Learners use the smokers' statistics and the history to tell which country is winning the smokers war.
Reflection	More time needed for content	Some learners need to grasp the content first.

Table 16 Teacher B: Lesson plan (Assignment 2)

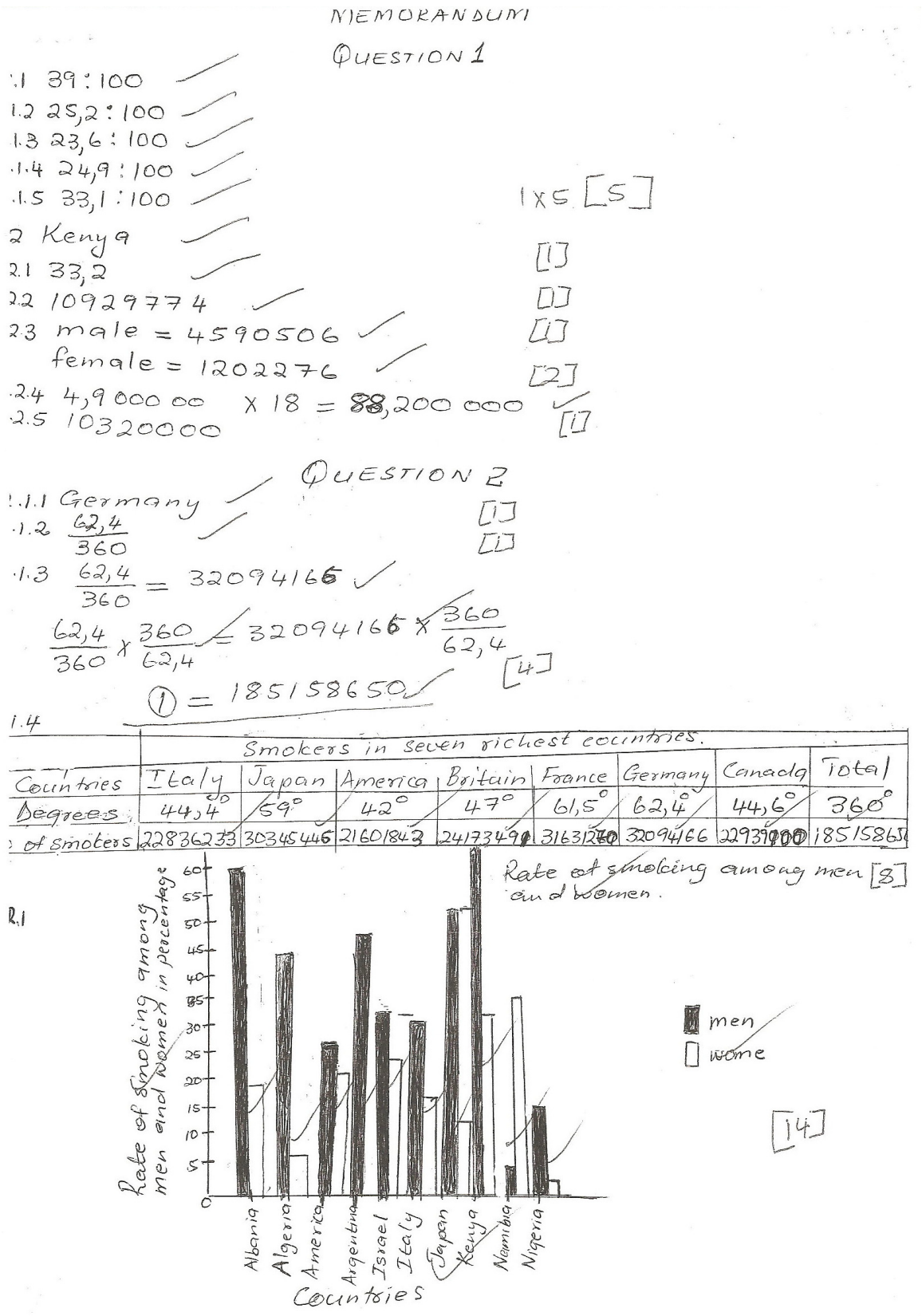
Teacher B developed the worksheet in Table 17 for the designed lesson in Assignment 2 (11 September 2007):

Worksheet		
	Question 1	
1.1	Express the total percentages of smokers from the following countries as a ratio:	(5)
1.1.1	Albania	
1.1.2	Algeria	
1.1.3	America	
1.1.4	Italy	
1.1.5	Japan	
1.2	From the table, which country has the highest percentage of smokers?	(1)
1.2.1	If 66.8 % of Kenyan men are smokers, how many percent are non-smokers?	(1)
1.2.2	South African population was estimated at 41 244 430 in 1995. If 26.5% are smokers, how many South Africans are smoking?	(1)
1.2.3	Based on your answer in 1.2.2 give the number of males and females.	(2)
1.2.4	In 1988 the world's population was estimated to be 5 billion. Given the statistic that say 4.9 million people die every year. Calculate the number of people who died as a result of smoking from 1988 to 2007.	(1)
1.2.5	In 1988 Nigeria's population was estimated at 120 million and based on the table of smokers, how many Nigerians are smoking?	(1)
	Question 2	
2.1	Smokers percentages in the seven richest countries on 20/10/02	
		
2.1.1	Which country has the most smokers?	(1)
2.1.2	What fraction of the diagram is this?	(1)
2.1.3	If 32 094 166 Germans are smokers, how many smokers are found in the seven richest countries in the world?	(4)

<table>
<tr><td>2.1.4</td><td>Work out how many smokers are found in each of the seven richest countries. Draw a table that will represent your answer.</td><td>(8)</td></tr>
<tr><td>2.2</td><td>
<table>
<tr><td colspan="3">Rate of smoking amongst adults</td></tr>
<tr><td>Country</td><td>Male %</td><td>Female %</td></tr>
<tr><td>Albania</td><td>60</td><td>18</td></tr>
<tr><td>Algeria</td><td>43.8</td><td>6.6</td></tr>
<tr><td>America</td><td>26.9</td><td>21.5</td></tr>
<tr><td>Argentina</td><td>46.8</td><td>34</td></tr>
<tr><td>Israel</td><td>33</td><td>24</td></tr>
<tr><td>Italy</td><td>32.4</td><td>17.3</td></tr>
<tr><td>Japan</td><td>52.8</td><td>13.4</td></tr>
<tr><td>Kenya</td><td>66.8</td><td>31.9</td></tr>
<tr><td>Namibia</td><td>6</td><td>35</td></tr>
<tr><td>Nigeria</td><td>15.4</td><td>1.7</td></tr>
</table>
</td><td></td></tr>
<tr><td>2.2.1</td><td>Draw a compound bar graph based on the data contained in the table.</td><td>(14)</td></tr>
<tr><td>2.2.2</td><td>Based on the table in 2.2.1 calculate the:
2.2.2.1 Mean
2.2.2.2 Range
2.2.2.3 Median
Use only the percentages of men.</td><td>(3)</td></tr>
<tr><td></td><td>Question 3</td><td></td></tr>
<tr><td>3.1</td><td>Fill in the table below:
<table>
<tr><td colspan="3">Rate of smoking amongst adults</td></tr>
<tr><td>Country</td><td>Total %</td><td>Degrees</td></tr>
<tr><td>Kenya</td><td>49.4</td><td>A</td></tr>
<tr><td>Namibia</td><td>50</td><td>B</td></tr>
<tr><td>Nigeria</td><td>8.6</td><td>C</td></tr>
<tr><td>South Africa</td><td>26.5</td><td>D</td></tr>
<tr><td>Haiti</td><td>9.7</td><td>E</td></tr>
<tr><td>Iran</td><td>15.3</td><td>F</td></tr>
<tr><td></td><td>Total 159.5 (160)</td><td>Total 360°</td></tr>
</table>
</td><td>(6)</td></tr>
<tr><td>3.2</td><td>Compare South Africa and Nigeria and state which country is winning the war against smoking. State what you think the country is doing.</td><td>(4)</td></tr>
</table>

Table 17 Teacher B: Worksheet (Assignment 2)

Teacher B provided a memorandum for the worksheet (Assignment 2, 11 September 2007). The memorandum is found in Figure 5 and Figure 6 on pages 102 and 103.



MEMORANDUM

QUESTION 1

.1 39 : 100
1.2 25,2 : 100
1.3 23,6 : 100
1.4 24,9 : 100
1.5 33,1 : 100 1x5 [5]

2 Kenya
2.1 33,2 [1]
2.2 10929774 [1]
2.3 male = 4590506 [1]
female = 1202276 [2]
2.4 4,9 000 00 x 18 = 88,200 000
2.5 10320000 [1]

QUESTION 2

1.1.1 Germany [1]
1.2 $\frac{62,4}{360}$ [1]
1.3 $\frac{62,4}{360} = 32094166$

$\frac{62,4}{360} \times \frac{360}{62,4} = 32094166 \times \frac{360}{62,4}$ [4]

① = 185158650

1.4

	Smokers in seven richest countries.							
Countries	Italy	Japan	America	Britain	France	Germany	Canada	Total
Degrees	44,4°	59°	42°	47°	61,5°	62,4°	44,6°	360°
of smokers	22836233	30345446	21601843	24173491	31631270	32094166	22939000	185158650

Rate of smoking among men and women. [8]

R.1

[14]

Figure 5: Teacher B Memorandum p1 (Worksheet for Assignment 2)

2.2.2.1 Mean = $\frac{383,9}{10}$

= 38,4%

2.2.2.2 Range = 66,8 − 6

= 60,8%

2.2.2.3 Median = 6, 15,4, 26,9, 32,4, 33 43,8 46,8 52,8 60 66,8

= 33 and 43,8

1X3 [3]

QUESTION 3

3.1

Country	total percentage	Degrees
Kenya	49,4	111,5° or 111.2°
Namibia	50	112,9° or 112,5°
Nigeria	8,6	19,4° or 19,4°
South Africa	26,5	59,8° or 59,6°
Haiti	9,7	21,9° or 21,8°
Iran	15,3	34,5° or 34,4°
	Total 159,5 or 160	360°

1X6 [6]

3.2. South Africa

The percentage of smoker is 26,5%

42% is men and 11,0% is women.

Men smoke more than women. This shows that it is still a taboo for women to smoke. ~~or~~ Liberal laws encourage smoki

Nigeria

The percentage of smokers is 8,6.

15,4% is men and 1,7% is women. Men smoke more than women. It shows that it is still a taboo for women to smoke The percentage is low the reason can be as a results of the laws which are governed by christian and Moslem faith which are strict.

1X4 [4]

TOTAL 52

Figure 6: Teacher B Memorandum p2 (Worksheet for Assignment 2)

5.4.7 **Lesson presentation (13 September 2007)**

Teacher B introduced the lesson presentation of the above lesson by handing out the data sheet on the rate of smoking amongst adults and stated:

> You know we have this problem of smoking. Unfortunately we have our country South Africa stated there.

After the introduction, Teacher B went straight into the maths and asked the learners to describe the concept of a percentage in their own words. He gave an informal definition by saying percentage is 'numbers out of a hundred'. He described the data in the tables as: the name of the country, total

percentage and then 'the information is further divided into male and female'. He referred to the data as statistics and claimed it is 'information divided into tables'.

Teacher B chose to make specific mention of the source of the data when he said:

> This information comes from the Rapport. It is a newspaper, Rapport. Who can tell me what is Rapport? It is an Afrikaans newspaper, you understand. And the date of that newspaper is the 20th of October 2002. We need to look at everything that is on the table so that we can deal with the information that is being presented by the table.

Focusing on mathematics, he asked the learners to explain the concept of ratio. He said:

> We use ratio to compare numbers. Ratios come from fractions. Percentages can also be written as ratios.

Then he explained the link between ratio, fractions and percentages. Teacher B stayed within the mathematics when he went on to discuss the drawing of graphs, the presentation of data and described the components learners need to draw a graph as follows: the heading, numbering of the y and x axis, y and x axis labels, plotting of the data and providing the scale.

Teacher B then mentioned the selection of data when he discussed comparing the data of African countries with European countries. Referring back to the data, he used an atlas to show the learners the location of Canada on the world map. He linked Canada to the G7 countries and asked: 'Do you know the 7 richest countries? We call them the G7 countries. Who can tell me what are those G7 countries?' The learners named the countries as America, Italy, Germany, France, Britain, Canada and Japan.

Teacher B further stated:

> Haven't you heard on TV when they say the G7 countries are meeting? There is a meeting of the G7 countries. The 7 countries are the ones that control the economy of the world. We listen to them. Even in South Africa we listen to them. They make decisions. Economic decisions on behalf of the whole world because they are able to sponsor some countries. You will find some day their presidents come together and they have a meeting. And one day they will invite our President Thabo Mbeki.

He showed the learners how to draw the bar graphs of the G7 countries using the total percentages of the G7 countries in the table. He also explained to the class how to round off the values before plotting the values on the graph.

Teacher B continued to work within the mathematics when he explained the drawing of a compound bar graph using America's male and female smoking percentages on the chalk board. He asked the learners to complete a compound bar graph for the male and female data for the other G7 countries. He then explained drawing a pie chart of the total percentages of the G7 countries by giving an example. This included the conversion of percentages to degrees, as well as estimating and actually

drawing the pie chart. He accentuated the mathematical skills of rounding off, estimation, working with a calculator, and measuring with a protractor.

Teacher B taught with the above-mentioned example, but the mathematical explanations were incorrect on two occasions:

1. He rounded 44.2248 off to 44.3 when he asked the learners to round off to the 1st decimal.
2. He indicated to the learners that one can only measure anti-clockwise when a pie chart is drawn with a protractor.

Teacher B discussed working with a calculator by asking the learners to 'press your calculator' when calculating the degrees of a pie chart sector that represents a certain smokers' percentage. Teacher B did not have enough time to teach the complete planned lesson.

5.4.8 Questionnaire 2 (October 2007) after the lesson presentation

In Questionnaire 2, completed after the lesson presented on 13 September, Teacher B explained that the nature and the purpose of Mathematical Literacy was:

> To ensure that our citizens are numerate consumers of mathematics. To be contributing workers. It is different (now compared to what I thought in February 2007) because I thought we were going to do mathematics and it's procedures to arrive at answers.

Teacher B commented on his teaching of Mathematical Literacy, in particular with respect to the smokers' data:

> I am now able to differentiate between maths and Mathematical Literacy. I am able to write meaningful lesson plans and know what I am teaching unlike before when I was teaching maths instead of Mathematical Literacy. At the beginning of the year I would only teach mean, median, tally etc and not focusing on the interpretation of tables and not even using data graphs to represent numerical data on graphs, charts etc. The smokers' data is an interesting context that enabled me to teach graphs, e.g. bar and pie, managed to deal with percentages, ratios and scales. Allowed a scope for interaction with economics and geography. The content allowed me to unfold the context. I used the maths content to explain what the context was all about. The content made sure that the context became meaningful because out of the context learners are able to draw graphs which enabled them to analyze the data provided in the context.

He described mathematics as:

> Scientific and emphasizes procedures at arriving to the answers while Mathematical Literacy uses mathematical understanding to solve problems that we are facing in our everyday life. It can be economic, geographic, etc.

When asked what aspects of the ACE Mathematical Literacy course helped him to unpack or think about the smokers' data and how to use it in his teaching, he claimed:

> The definition, the nature and purpose of Mathematical Literacy as a learning field. The mathematical activities we have done so far.

5.4.9 **Interview (May 2008)**

In the Interview (May 2008) with Teacher B, he explained his understanding of Mathematical Literacy and how his understanding of the nature and purpose of Mathematical Literacy had changed over time. B is Teacher B and J is the interviewer.

> B: In the beginning I did not know what I was doing. I was actually thinking that I was just teaching mathematics. Mathematical Literacy is meant to apply the little mathematical knowledge that learners have gained from the lower grades to the situations that they are faced with in real life.

Commenting on the difference between the teaching of mathematics and Mathematical Literacy, he said:

> B: I mean before I enrolled for this course Mathematical Literacy was just ordinary maths, scientific maths. I would have taught learners equations, I would have taught learners factorisation, and so on. (Now) The content must be chosen to solve the context. You just put the context before the content. You only resort to the content when you try to solve the context.

Teacher B commented on his teaching of Mathematical Literacy with the smokers' data, in particular with respect to the role of contents and context.

> B: That contexts enabled me to show learners how to plot graphs which is a mathematical content…..I was not directly teaching them graphs. In teaching the context they happen to learn about the mathematical content of graphs, how to draw graphs, how they are plotted and so on.
>
> J: What do you think you might you have done previously?
>
> B: In the beginning of the year there was this confusion about Mathematical Literacy and maths. One couldn't separate the difference. I would have focused on the mathematics directly; I would say how to draw a graph, the X and Y axis. And show them how to plot a graph.

Teacher B explained unpacking the financial context in a Mathematical Literacy lesson in the following quote:

> B: I think when you teach learners about making choices when it comes to opening bank accounts you explain the language the bank uses to hide some of the realities that the learners cannot see; that ordinary people cannot see. So when you unpack all those languages to the learners you realize that whatever bank account that they have opted for between, they should have opted for bank X or Y. Also when you talk about shopping. Those discount that they place. Somewhere the shop owner can hide the information to show the profit.

In the interview I probed Teacher B to describe his view regarding moral and ethical values within the Mathematical Literacy lesson.

> J: What made you choose the heading 'the war against smoking' in Portfolio 1 (20 February)?

B: Smoking is a problem the whole world. All the nations of the world are trying to solve this problem. It is causing health problems to all people. When you look at people who are smoking; they start smoking when they are teenagers. We are teaching teenagers who are also having problems with smoking. Now for them to stop smoking we need to teach them at school. So that we shall have a population of non-smokers.

Teacher B described other contexts in which he had taken a personal stance and how he dealt with the context when teaching Mathematical Literacy:

B: Yes. Teenage pregnancy. That I handled like smoking. I just gave them statistics, but they were not real statistics. I couldn't access the internet to give them maybe the national statistics on teenage pregnancy in the schools. Then we drew graphs and pie charts and did an analysis on the graph. They were telling me about a trend. Business/ Finances. How they control their finances. How can they draw up a budget?

J: Did it push you to express a personal opinion?

B: Yes. We are coming from a nation that does not budget. Then this is a national problem. That is why the Governor is increasing the interest rates and we are always in debt because we just spend the money without even budgeting. We need to start teaching our learners the right budget so that when they grow up they shouldn't be like us.

J: Do you share it with your class? How?

B: You bring it as a lesson in the class and then you get their feelings. But you just direct them. They give you their feelings. How do they feel? What can we do to stop that? Then they come up with ideas. And you add your own ideas. Then we come up with the feeling of the class. Some people will differ with you. Not all the learners will support what you are saying. Some of them might be supporting you because you are an adult, but you look at their responses.

J: Do you think it is important to share your values, moral opinion with the class?

B: Yes, if you share your moral opinion with the class, learners does not look at you as an authority on some of the views. You give them a chance to express their views, but you guide their views. And the decision will come from the class. Because if you come and impose your opinion on the class you become the source of information. You go back to the type of teaching we are coming from. The teacher has the information and there is no information that will come from the learners.

In the next sections an overview and a detailed analysis of Teacher B's case study is presented.

5.5 Overview of Teacher B's story

Teacher B showed good scholarly understanding regarding the definition and purpose of Mathematical Literacy with respect to the learning component of meaning (Wenger, 1998). Evidence in the course assessment tasks (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007 and Assignment 2, 11 September 2007) suggested that he understood the new Mathematical Literacy curriculum and experienced it as meaningful, and that he talked about ways of teaching the curriculum. Initially (February 2007) Teacher B largely described Mathematical Literacy by restating the NCS for Mathematical Literacy (DoE, 2003a) and information on the

internet (wikibooks). In April 2007, it was apparent that he revealed wider knowledge regarding the subject since he quoted from the international literature that was provided as part of the ACE Mathematical Literacy course. Largely, like Teacher A, he appeared to restate the curriculum documents and ACE course readings, but to a greater degree than Teacher A in his own voice.

Teacher B followed a largely mathematical style in lesson planning and worksheets construction (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and for teaching practice (Lesson presentation, 13 September 2007) in the Mathematical Literacy classroom. Teachers B sometimes scaffolded the learners with respect to the mathematics in the Mathematical Literacy classroom. The teacher largely worked in a mathematically coherent style and sometimes referred to the use of the calculator in the classroom. His tasks predominantly included a contextually sensitive selection of context which he used when teaching Mathematical Literacy.

Initially Teacher B appeared to have a largely mathematical focus with some evidence of contextual integration with respect to his planning (Portfolio 1, 20 February 2007; Questionnaire 1, 20 February 2007; Assignment 2, 11 September 2007) and classroom practice (Lesson presentation, 13 September 2007) of a Mathematical Literacy lesson. Evidence of attempts to do contextual integration was evident in his early tasks when he asked learners to draw conclusions, therefore interpret answers, in activities 5 and 7 of the teaching ideas submitted for Portfolio 1 (20 February 2007). Teacher B's snapshot of Mathematical Literacy teaching practice could be described as a practice where he used the contexts as a vehicle to do the mathematics and enhance mathematical understanding. In the interview in May 2008 he stated that he had a more context-orientated view with respect to the teaching of Mathematical Literacy, therefore suggesting that his view had changed regarding the emphasis on context and content. According to Teacher B's lesson planning, assessment tasks and lesson presentation (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007; Lesson presentation, 13 September 2007) he appeared to largely work in the Mainly content driven agenda (Graven and Venkat, 2007).

As mentioned before, the theme of ethics and moral values emerged spontaneously from the empirical data collected for Teacher A; however this was not the case with the data collected for Teacher B. I decided to include the theme on ethical and moral values in this study and purposefully flagged up the theme in Teacher B's second informal questionnaire (Interview, May 2008).

5.6 Analysis of Teacher B's story

The matters raised in the above section are discussed further in the analysis below. For Teacher B, these issues could be categorized according to the subcategories shown below. The categories largely overlap with Teacher A's categories, but some differ. The categories are the following:

1 Meaning of Mathematical literacy

- Communication of information and development of own voice
- Restatement of the curriculum documents and course readings
- The link between Mathematical Literacy and mathematics
- The relationship between mathematical content and context

2 Mathematical Literacy teaching practice

- Analysis of questions set by Teacher B
- Analysis of the mathematics in Teacher B's classroom practice
- Evidence of scaffolding
- Mathematical coherence and progression
- Mathematical Literacy and abstract mathematics
- The relationship between mathematical content and context
- The use of technology
- Ethical and moral values

5.6.1 Meaning of Mathematical Literacy

The section on meaning relates to aspects of Teacher B's understanding of the nature and purpose of Mathematical Literacy and the way he sees the relationship between mathematical content and context.

5.6.1.1 Communication of information and development of own voice

Teacher B emphasized the notion of Mathematical Literacy as a subject where 'learners will be able to make sense of information communicated in tables, graphs, diagrams and texts.' (Portfolio 1, 20 February 2007). He further emphasized the link between Mathematical Literacy and the graphical communication of information in Questionnaire 1 (February 2007) when he claimed:

> Information in this world is communicated through tables and graphs. Mathematical Literacy enables learners to be able to understand the manner in which information is communicated.

Later on (Lesson presentation, 11 September 2007) Teacher B claimed 'information is divided into tables … we need to look at everything that is on the table so that we can deal with the information that is being presented by the table.'

It might be noted that Teacher B shared the view that tables and graphs represent information in different ways. The use of more than one mathematical representation is described by Ball, Bass and Hill (2004, p59) as a good teaching practice for the teaching of mathematics.

Teacher B stated that Mathematical Literacy might enable learners to understand these representations of information, in particular tables and graphs. Hence, if learners were able to understand the way information is communicated, they might make sense of the information. The ability to understand the tables and the graphs is seen as a teaching goal in itself. On the other hand, Pugalee (1999) states that communication is identified as one of the three enablers that facilitate the teaching of Mathematical Literacy. According to Pugalee communication is a 'tool that assists students in the development of mathematical understanding.' Hence it might be noted that he assumed that learners will understand the way information is communicated since it could be used as a tool (enabler) for understanding the mathematics embedded in the tables and graphs.

Teacher B reflected his personal take (Questionnaire 1, 20 February 2007) on the Mathematical Literacy task with the words that he 'felt confused and did not know where to start.' This admission of his confusion (when he received the task which included the table of information) stood opposed to his view that Mathematical Literacy should enable learners to understand tables and graphs. This indicated a contrast between his academic understanding of the teaching of the lesson, and his practical understanding of how the lesson should be taught.

Teacher B's statements tended to give preference to the mathematical content in the classroom (Questionnaire 1, 20 February 2007). He stated for example:

> I did not know whether I should start with the emphasis on the graphs or should I concentrate on the median, mean and mode but at the end I tackled both. I integrated it with geography.

For him the choice seemed to be which mathematical representation he should use: graphs or the measures for central tendency. These were alternative mathematical foci since the graphs focused on the graphical representation of the data, and the median, mean and mode provided a summary of the data. The context, which he integrated with geography, was the place where the mathematics was located and served as a vehicle for the mathematics.

Teacher B's view on Mathematical Literacy developed over time. In the Questionnaire 2 (October 2007) he changed his opinion regarding his mainly mathematical orientation to become more contextually inclined when teaching Mathematical Literacy. He wrote:

> I thought we were going to do mathematics and it's procedures to arrive at answers, …before ... I was teaching maths instead of Mathematical Literacy, … at the beginning I would only teach mean, median, tally, etc and not focusing on the interpretation of tables.

This statement indicated a shift from his previous statement in Questionnaire 1 (20 February 2007), where he focused his Mathematical Literacy teaching on the teaching of the mathematics, in particular on measures of central tendency and graphical interpretations of data; therefore following a more mathematics-orientated approach. In May 2008 his view with respect to the teaching of Mathematical Literacy appeared to be even more biased towards the context when he stated 'you only resort to the content when you try to solve the context' (Interview, May 2008). To summarise: initially his focus was mainly on the mathematics in the Mathematical Literacy classroom, later on context and content, and in May 2008 it appeared that his view was more context-orientated. This shift is discussed further under the heading of Teacher B's Mathematical Literacy teaching practice below.

In Portfolio 3 (13 March 2007) Teacher B expressed a more personal voice when he claimed that Mathematical Literacy would enable more learners to have access to mathematics and might provide learners, who were not previously in such a position, access to tertiary education. He stated:

> The purpose (of Mathematical Literacy) is to address the declining number of learners who are consumers of mathematics and also to offer learners who are interested to do courses at higher levels (tertiary) which do not have significant mathematical content, an opportunity to do mathematics at school level.

5.6.1.2 **Restatement of the curriculum documents and course readings**

As pointed out in the previous paragraph, Teacher B sometimes shared his own voice when asked to present his view regarding the nature and purpose of Mathematical Literacy, but there is evidence that he frequently echoed the curriculum documents (DoE, 2003a) and course literature.

Initially (Portfolio 1, 20 February 2007), he gave a policy-oriented definition of Mathematical Literacy that indicated that he had access to information resources such as the internet, more specifically 'wikibooks'. He said:

> Mathematical Literacy is defined as a subject which provides learners with an awareness and understanding of the role that mathematics plays in the modern world.

Teacher B's description of Mathematical Literacy (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007), showed a clear overlap with the NCS for Mathematical Literacy (DoE, 2003a, p 9) when he nearly quoted the policy document. He simply re-worded the definition and purpose as described by the curriculum document (DoE, 2003a) when asked for his written understanding of the subject. However, Teacher B quoted less overtly from the curriculum documents than Teacher A.

In Assignment 1 (10 April 2007) he continued to defer to curriculum speak when he chose a question that was taken straight from the NCS Mathematical Literacy Grade 10 Paper 2 (DoE, 2006) as an example of a Mathematical Literacy task for the ACE Mathematical Literacy course. He did not

answer the question from his personalised experience in the teaching of Mathematical Literacy, but preferred to choose a question from the curriculum document.

Teacher B re-voiced the readings he was given as part of the course notes in the ACE Mathematical Literacy course in the course assessment (Assignment 1, 10 April 2007). He paraphrased Steen (2001) in particular in stating: 'It (Mathematical Literacy) involves real data and procedures which are not prescribed and requires elementary maths.' This could have been expected in the situated context of the formal assessment of the ACE Mathematical Literacy course.

Later in the year (Questionnaire 2, October 2007), Teacher B explained that the purpose of Mathematical Literacy was 'to ensure that our citizens are numerate consumers of mathematics. To be contributing workers.' He therefore still deferred to curriculum speak, however he did add his own opinion as follows: 'Mathematical Literacy use mathematical understanding to solve problems that we are facing in our everyday life. It can be economic, geographic, etc'.

It might be noted that Teacher B, like Teacher A, showed a good scholarly, academic engagement with the NCS for Mathematical Literacy (DoE, 2003a) and the course readings. He sometimes used his own voice when he described Mathematical Literacy and the purpose of the subject. This could indicate a movement towards ownership; however he frequently fell back on the curriculum documents (DoE, 2003a) and course readings (Steen, 2001).

5.6.1.3 **The link between Mathematical Literacy and mathematics**

Teacher B described Mathematical Literacy as a context-based subject which uses mathematical understanding and content to solve problems in the context (Portfolio 3, 13 March 2007; Questionnaire 2, October 2007). Hence, he saw mathematics as a tool for understanding and solving the context when teaching Mathematical Literacy.

When asked to describe the difference between mathematics and Mathematical Literacy, Teacher B explained the difference by referring to the calculation of simple interest in Portfolio 3 (13 March 2007). He stated: 'in mathematics the procedures and methods are the things that are mainly emphasized' and 'in Mathematical Literacy the simple formulae can be used so that the learner can make a decision in a given context'. Therefore in Mathematical Literacy the simple interest formula might be used when learners calculate interest over time from basic principles, whilst mathematics was described as focused mainly on procedures and methods.

In Portfolio 3 (13 March 2007) Teacher B stated Mathematical Literacy gave learners tools to use to make informed real-life decisions; he stated 'these concepts and contents are not being treated in mathematics.' Therefore Teacher B claimed that mathematics and Mathematical Literacy did not show an overlap. In contrast, in Assignment 1 (10 April 2007) he acknowledged a link between mathematics and Mathematical Literacy in stating that grade 9 mathematics contents 'is regarded as significant for the learner to apply in Mathematical Literacy.'

5.6.1.4 The relationship between mathematical content and context

In Portfolio 3 (13 March 2007) Teacher B emphasized that the context was where the mathematics took place. 'Mathematical Literacy, he claimed, is a subject which is context based and uses mathematics content to solve the context'. Fithteen months later (Interview, May 2008) he added: 'the content must be chosen to solve the context.' It might be noted that he viewed context and mathematical content as necessary components of Mathematical Literacy teaching practice.

In the section that follows Teacher B's teaching practice is analysed in detail.

5.6.2 Mathematical Literacy teaching practice

The headings for this section follow directly from the critical questions of this study and emerged from the analysis of the data collected with respect to Teacher B's Mathematical Literacy teaching practice.
In the first section on Mathematical Literacy teaching practice I present an analysis of the questions for the teaching ideas included in Portfolio 1 (20 February 2007) and the worksheet for Assignment 2 (11 September 2007). As with Teacher A, the analysis on the clarity, types and level of questions included in the written assessment tasks emerged indirectly from the research question on how Mathematical Literacy is taught in the classroom and is used to determine the nature of his assessment tasks.
The analysis is followed by a discussion on the mathematics in Teacher B's Mathematical Literacy teaching practice, analysis on the evidence of scaffolding, and mathematical coherence and progression.

This is followed by an analysis that relates to how Teacher B saw the relationship between mathematical content and context in his lesson planning and lesson presentation. I refer to Teacher B's contextually sensitive selection of context, style and order when working with the components of context and content and the connection between his teaching practice and the spectrum of agendas (Graven and Venkat, 2007).

Thereafter reference to the use of technology and ethical and moral value discussions is considered. Ethical values discussions emerged very strongly from Teacher A' data, but not to the same degree in Teacher B's data. However, I used Questionnaire 2 (October 2007) as a frame to probe and further investigate Teacher B's views on ethical and moral values.

5.6.2.1 Analysis of questions set by Teacher B

The analysis in this section links to Teacher B's tasks for assessment of Mathematical Literacy. The questions for the smoking context in the activity in Portfolio 1 (20 February 2007) and the worksheet for Assignment 2 (11 September 2007) were analysed according to the same categories used previously:

1. The nature of the question, specifically whether the question has a content or contextual orientation

2. Clarity of questions and whether the mathematics is purposeful in relation to the context
3. The cognitive level of questions according to the Mathematical Literacy taxonomy in the Subject Assessment Guidelines (DoE, 2008, p27-28) and Stein et al. (2000), where applicable

A summary of the types of questions and cognitive level of questions in the activity in Portfolio 1 (20 February 2007) and worksheet in Assignment 2 (11 September 2007) is given in Table 18. Comments on the clarity of the questions are pointed out in the section on the nature of questions.

	Types of questions		**Cognitive level of questions**				
	Contextual questions	Mathematical questions where the context is in service of the mathematics	Knowing	Applying routine procedures in familiar contexts	Applying multistep procedures in a variety of contexts	Reasoning and reflecting questions	Low-level reflective questions
Portfolio 1	22%	78%	45%	22%	11%	0%	22%
Assign. 2	7%	93%	28%	53%	11%	0%	8%

Table 18 Teacher B: Types and cognitive level of questions

The description of the types and cognitive level of questions were provided in the section for Teacher A on p78. The percentage allocation per cognitive level for Portfolio 1 (20 February 2007) was done with respect to the number of questions in the assessment task since no marks were allocated for questions. The mark allocation percentage per taxonomy level for the worksheet (Assignment 2, 11 September 2007) was used to determine the percentage of questions on a specific cognitive level.

Overview of the nature of and clarity of questions

The written teaching ideas (Portfolio 1, 20 February 2007) and the worksheet (Assignment 2, 11 September 2007) focused predominantly on mathematical questions where these mathematical tasks were embedded in the context provided. The mathematical questions used the context as a vehicle to do the mathematics. An attempt to integrate context with mathematical content was seen in activities 5 and 7 of Portfolio 1 (20 February 2007). These questions involved contextual interpretation of answers since learners were asked to draw conclusions based on their answers.

According to Table 18, Teacher B seemed to include a higher percentage of mathematical questions in the worksheet for Assignment 2 (11 September 2007) compared to the teaching ideas expressed earlier the year in Portfolio 1 (20 February 2007). Furthermore, as stated before, the teaching ideas

showed more evidence of contextual integration than the questions for the worksheet. Careful and coherent selection of context was often observed.

As was the case with Teacher A, some questions showed discrepancies in wording and mathematical precision. These mathematical questions could be described as 'badly set' questions.

Overview of the cognitive level of questions

Eighty nine percent of the activities for the task (Portfolio 1, 20 February 2007) and for the worksheet submitted for Assignment 2 (11 September 2007) could be classified as level 1 and 2 questions or low-level reflective questions, therefore questions that require a lower cognitive demand. According to Table 18 Teacher B had a higher percentage of questions on the 'applying routine procedures in familiar contexts' level and a lower percentage of questions on the 'knowing' level in the worksheet (Assignment 2, 11 September 2007) if compared to the activity earlier on the year (Portfolio 1, 20 February 2007). For both assessment tasks, 11% of the questions could be classified as 'applying multistep procedures in a variety of context' and no 'reasoning and reflection' questions were included.

The reflective questions in the activity and the worksheet (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) were on a low cognitive level since these questions required minor mathematical reasoning and might not be suitable for Mathematical Literacy tasks, however, the percentage of low-level reflective questions was lower in the second assessment task compared to the task earlier in the year. Overall, the cognitive level of the questions for the second task (Assignment 2, 11 September 2007) was slightly higher than for the first task (Portfolio 1, 20 February 2007). It can be noted that Teacher B developed his skill of setting Mathematical Literacy questions since he incorporated more higher cognitive demand tasks.

As was the case for Teacher A, the assessment tasks set by Teacher B were not set according to the allocation per cognitive level for examination tasks as prescribed by the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008, Venkat and Phungula, 2008).

In the main Teacher B's mathematical questions seemed clear and coherent. This was evident from the way the questions built on each other with respect to the cognitive level of the questions. Reasoning was often necessary to answer 'apply routine procedures in familiar contexts' and 'apply multistep procedures in a variety of context' questions as observed in the above assessment tasks. This agrees with the view held by Venkat et al. (2009) that reasoning is a skill necessary for all level of questions. It appeared that he was strongly influenced by the text book that he used in the classroom.

The detail question analysis on the nature, clarity and cognitive level of questions follows in the next two subsections.

The nature and clarity of questions

The detailed question analysis relates to the nature and the clarity of questions asked in relation to context and content for the teaching ideas in Portfolio 1 (20 February 2007) and the worksheet for Assignment 2 (11 September 2007).

Teaching ideas for Portfolio 1 (20 February 2007)

In Portfolio 1 (20 February 2007) the majority of the proposed activities (2-8) in Table 14 on p96 were mathematical tasks. These questions largely used the context as a vehicle to accomplish a mathematical goal; therefore the context is in service of the mathematics. As pointed out previously, activities 5 and 7 showed some evidence of a proposed link between the context and the mathematics where learners were expected to draw conclusions based on the mathematics they did. However, these questions did not deepen both the mathematical and contextual understanding and could therefore not be classified as dialectical questions.

Activity 2 and 3 required the skill of reading off the given table and to arrange the data in order to calculate the measures of central tendency asked in activity 4; therefore activities 2 - 4 might be classified as mathematical tasks.

The wording for activity 5 was unclear since it asked that the 'percentage of the African men smokers will be compared with the average of European men smokers'. Learners were asked to compare the averages, therefore it might be assumed that the teacher intended to refer to the average percentage of African men smokers.

In activity 6 the wording 'top ten countries of high smokers' was not clear, but it was assumed that learners needed to identify the ten countries with the highest total percentage of smokers and to represent the data on a bar graph. Teacher B then asked them to repeat the exercise for the six African countries. The purpose for the activity appeared to be mathematical. The repetition with a second chart might indicate a view that learners needed to practice the skill of drawing a bar chart. No follow-up contextual questions were asked in terms of the comparison of the two charts in this case.

Teacher B then shifted to another type of graphical representation of the data when he asked for a pie chart of the female percentages from the six African countries in activity 7. The purpose for this activity again appeared to be mathematical since the learners should have been able to draw conclusions from the percentages given in the table without drawing the pie chart. Learners were requested to investigate the data since they were asked to draw conclusions from the graph.

Activity 8 appeared problematic since learners only had access to the percentages (in other words proportion) of smokers in a country; and not the population numbers or profits on tobacco sales. The reasoning was mathematically problematic since high smoker percentages do not necessarily imply a high number of smokers or a high production of cigarettes. Smoker numbers were necessary to

identify which countries might make high profits on cigarette sales, but such information was not available.

Activities 1 and 9 might be seen as contextual questions. Activity 9 appeared to be a task with a contextual purpose in mind since the smoking context was investigated and unpacked further. There is, however, no reference as to whether the investigation included contextual data and/or mathematical activities or whether contextual decisions would be influenced by mathematical calculations (if any).

Teacher B appeared to make specific selections of context for the different activities. In activities 3, 4, 5 and 7, Teacher B made reference to gender, and in activities 6 and 8 to the top ten smoking countries. In activities 5, 6 and 7 the choice of African countries might represent an attempt at localisation, but this could not be stated with certainty. The data selections from the context appeared sensible and were utilized as 'vehicles' for different mathematical content that Teacher B intended to cover.

Worksheet for Assignment 2 (11 September 2007)

The questions in Assignment 2 (11 September 2007) in Table 17 on p101 might largely be classified as mathematical questions where the context is in service of the mathematics. In comparison with Teacher B's earlier teaching ideas (Portfolio 1, 20 February 2007), the mathematical and contextual activities for the worksheet in Assignment 2 (11 September 2007) appeared to show slightly less integration and were kept more separate.

Questions 1.1, 1.2.1, 1.2.2, and 1.2.5 of the worksheet (Table 17) required read-off from the table and/or simple mathematical calculations. In question 1.2.2 and 1.2.5 the learners were asked to determine the number of smokers in South Africa and Nigeria respectively when the percentage of smokers and the estimated population were given. These questions indicated an awareness of the difference between percentage and number. The selection of African countries for question 1.2.1, 1.2.2, and 1.2.5 might have indicated a level of localisation.

Question 1.2.3 was 'based' on the answer in question 1.2.2 where the total number of South African smokers was calculated for 1995. In the case of South Africa the overall smokers' percentage is the mean of the male and female percentages given in the data sheet, therefore the assumption could be made that the number of males: number of females in South Africa is in a ratio of 1:1.

In Question 1.2.4 it was accepted that the 4.9 million people die every year and the number stays the same every year from 1988 to 2007. This reasoning was verified in the memorandum for the worksheet in Figure 5. The question did not allow for any escalation/change of the number of smokers per year – which may be a problematic assumption. Hence the given information was not authentic with respect to the context of population growth. The choice of wording of the question indicated that

the ‘authenticity of context was sacrificed so as to meet maths goals’ (Graven and Venkat, 2007) and the context was merely used as a vehicle to do the mathematics.

In the pie chart in question 2.1 learners were given the degrees of the smokers’ percentages of the seven richest countries in the world, not the smokers’ percentages. The question was confusing since the heading of the question states ‘smokers’ percentages of the seven richest countries’. The choice of the seven richest countries was contextually sensitive and it indicated a reference to the wealth of countries globally.

Question 2.1.1 asked for the country with the ‘most’ smokers, in other words the country with the highest number of smokers, although only the smokers’ percentages (or degrees) in the countries were given, not population numbers. Learners would not be able to answer the question with the given information and therefore the mathematical representation might be misleading. Question 2.1.2 appeared to be asked with a purely mathematical purpose.

In question 2.2 and 3.1 the countries appeared to be selected randomly. No reference was made to localisation when the teacher selected the data and it appeared that the countries were chosen with no specific contextual sensitivity in mind. These questions appeared to be asked with a mathematical purpose in mind since the learners were asked to draw a graph, calculate measures of central tendency and convert the total percentages to degrees, without linking the answers to the calculations back to the context again. In question 2.2.2 the measures of central tendency were calculated for male data only.

Question 3.2 could be classified as a contextual question. In the question learners were asked to compare South Africa and Nigeria and ‘state which country is winning the war against smoking’ and give a reason for the answer. According to the lesson plan learners were asked to use the smokers’ statistics and history referring to religion, society, economy, population, etc., to determine which country was winning the smokers’ war. This was also evident in the memorandum for the worksheet in Figure 6. The question seemed to involve the comparison of percentages from the table and then linking the answer back to the smokers’ context again; therefore the question appeared to have a contextual purpose.

The level of questions in assessment tasks

As with Teacher A, I did a deeper analysis of the cognitive level of the questions in the assessment tasks of Teacher B. The assessment grid for the taxonomy level of questions for the teaching ideas in Portfolio 1 (20 February 2007) in Table 14 on p96 and for the questions in Assignment 2 (11 September 2007) in Table 17 on p101 is presented in Table 19:

Taxonomy level	Portfolio 1 questions	Assignment 2 questions (53 marks)
Knowing	1, 2, 3, 9 (45%)	1.1, 1.2, 1.2.1, 2.1.1, 2.1.2, 3.1 (15 marks - 28%)
Apply routine procedures in familiar contexts	4, 6 (22%)	1.2.2, 1.2.4, 1.2.5, 2.1.4, 2.2.1, 2.2.2 (28 marks – 53%)
Applying multistep procedures in a variety of contexts	7 (11%)	1.2.3, 2.1.3 (6 marks - 11%)
Reasoning and reflecting	(0%)	(0%)
Low level reasoning	5, 8 (22%)	3.2 (8%)

Table 19 Teacher B: Assessment grid (Activity, Portfolio 1; Assignment 2, 11 September 2007)

Teaching ideas for Portfolio 1 (20 February 2007)

The calculation of the median (activity 4) can be classified as 'applying routine procedures in familiar contexts' since the teacher scaffolded the learners when he asked them to rank the countries with respect to smokers' percentages in the previous activity 2. If the learners were not scaffolded to rank the data the calculation of the median might have been classified as a multistep procedure question.

In activity 5 learners were expected to draw conclusions based on the calculation of the averages; in other words they had to substitute values into a formula, calculate the answer and reflect on the answer of the calculation. The question could be classified as a reflective question which required some mathematical reasoning.

Activity 6 can be classified as 'applying routine procedures in familiar contexts' since learners had to represent the ten countries with the highest total percentage of smokers and the six African countries on a bar graph, without analysing the graphs.

Activity 7 can be classified as a multistep procedure activity since learners were required first to calculate the number of degrees that represent the percentage of female smokers in each African country; thereafter learners used the degrees to draw the pie chart and then draw conclusions based on the representation.

Activity 8 was a reflective question which might, or might not, require reasoning with respect to mathematical calculations done in earlier questions. Therefore it might be classified as a low-level reflective question (Venkat et al. 2009).

Worksheet for Assignment 2 (11 September 2007)

Question 1.2.3 can be classified as a multistep procedure question since learners first had to assume the ratio male:female smokers to be 1:1, and then calculate the number of male and female smokers, based on the given percentages.

Question 2.1.3 can be classified as a question that required multiple procedures since it asked learners to first calculate the number of German smokers that were presented by one degree in the pie chart and thereafter calculate the total number of smokers for the each of the seven richest countries in the world. In question 2.1.4 learners had to calculate the number of smokers in each of the countries. I classified it as 'apply routine procedures in familiar contexts' since the calculation was similar to the calculation in question 2.1.3.

Question 3.2 could be described as a low-level reasoning question (Venkat et al. 2009). Learners were asked to do contextual reasoning and then to make a judgement. Learners had access to the smokers' percentages in the given table, but were not specifically required to do mathematical calculations or to use mathematical concepts comprehended at a previous cognitive level in order to make a decision.

Teacher B mainly used a mathematical, although more contextually sensitive frame, when he set the written assignment for Assignment 2 (11 September 2007). Therefore Stein et al.'s (2000) mathematical framework for assessment could also be used as a frame to classify the questions in the assignment. Eighty nine percent of the questions were classified as Lower-level demand tasks (memorization tasks and procedures without connections) and 11 % questions as Higher-level demands tasks (procedures with connections and doing mathematics).

5.6.2.2 Analysis of the mathematics in Teacher B's classroom practice

Teacher B, as opposed to Teacher A, gave early evidence in Questionnaire 1 (20 February 2007) that he had taught Mathematical Literacy using the smokers' data, although it was not required from the ACE teachers. In Questionnaire 1 (20 February 2007) Teacher B planned to start his teaching within the mathematics, either focussing on graphs or central measures of tendency. He then planned to move towards the context, more specifically the map location of countries, but did not engage with the smoking context in particular. Teacher B referred to his teaching experience, stating:

> It was a bit difficult more especially when teaching learners who can't draw graphs with correct scales. You deviate a lot on the development of graphs. It becomes easier when learners master the graphs.

It can be noted that Teacher B did not see the teaching of the drawing of graphs as part of his core lesson plan since he expected that the ability to draw graphs was part of learners' prior knowledge. This quote indicated that he could not follow his original lesson plan, but had to deviate from it by spending time on the explanation of the mathematical content.

In the lesson presentation (13 September 2007), Teacher B explained the mathematical concepts of percentage, ratio and fractions, highlighting the different representations of the same concept (Ball et al., 2004). Teacher B used the context as a vehicle to explain the drawing of bar graphs, compound bar graphs and a pie chart. He chose meaningful selections of context as a contextual frame, but the classroom activities were largely done with a mathematical purpose.

5.6.2.3 Evidence of scaffolding

Teacher B structured his lesson plans and tasks to scaffold the learners towards achieving the desired lesson outcomes. The notion of scaffolding was visible in the teaching ideas in Portfolio 1 (20 February 2007) in Table 14, the worksheet that is part of Assignment 2 (11 September 2007) in Table 17, developed for ACE Mathematical Literacy assessment purposes and in the presentation of the lesson (13 September 2007). The learner-support and scaffolding is pointed out in bold in Table 20:

Data collection instrument	**Exert from data**
Portfolio 1 (20 February 2007)	Activity 2: Countries **will be ranked** from the one with the highest percent of smokers to the one with the lowest percent of smokers. (**The aim is to make easier for the calculation of the median**). Activity 3: Learners will further be **requested to rank** countries in terms of the highest and the lowest female and male percentages of smokers. After this has been done, **learners will be shown** how to calculate the arithmetic mean, median and the mode.
Assignment 2 (11 September 2007)	Explain ratio 1:2 and what does it mean. Write percentage as a ratio. **Show the learners** how to use protractor to measure angles. Plot coordinates on the graph. After a bar graph of the seven richest countries is drawn, '**learners will be shown** the existing differences in terms of smokers'.

Table 20 Teacher B: Evidence of scaffolding and learner support

In Portfolio (20 February 2007), the scaffolding occurred when learners were first asked to rank the data; then to calculate the median. Teacher B pointed out that the aim of the ranking was to simplify the calculation of the median. He then stated 'learners will be shown' how to calculate the measures of central tendency. It appeared that he intended to scaffold the learners in the process that was

needed to follow when these measures were calculated. He showed them before requiring them to do the calculations on their own. Furthermore, he noted in the above section that he had to deviate from his teaching ideas (Portfolio 1, 20 February 2007) to explain the mathematical concept of the 'drawing of graphs' (Questionnaire 1, 20 February 2007) before bringing in the contextual data.

In Assignment 2 (11 September 2007) can be seen that the teacher attempted to guide or scaffold the learners since he planned to show the learners how to measure angles with a protractor and to explain the bar graph that had been drawn. The aim was to guide and scaffold the learners. The notion of learner support was also evident in the lesson plan (Table 16) of Assignment 2 (11 September 2007) when he anticipated a reflection on the lesson plan and that more time would be needed for content and that 'some learners need to grasp the content first'.

Further evidence of scaffolding manifested in the lesson presented on 13 September 2007. Teacher B showed the learners by example how to draw the bar graphs of the G7 countries using the total percentages of the G7 countries in the table. The class explanation on how to round off the values before plotting the values on a graph served a pedagogic purpose since he illustrated the procedure before he required the learners to attempt the task.

Scaffolding and learner guidance were offered to support learners in the understanding of the mathematical content used to solve the context. This way of teaching enabled learners to construct contextual and mathematical meaning and understanding when they solved Mathematical Literacy problems.

5.6.2.4 **Mathematical coherence and progression**

The lesson plans and tasks set by Teacher B appeared to be largely mathematically coherent. This was clear since the activities followed each other in a reasoned and progressive manner. The following examples can be mentioned:

In Portfolio 1 (20 February 2007) learners were asked to rank the smokers' percentages, then calculate the median, mean and mode, thereafter to compare the measures of central tendency and then to draw conclusions based on the data. After the calculations learners were asked to present the data on a bar and a pie chart and again draw conclusions on what they observed. The order of the activities set in the task made mathematical sense and followed in a coherent, extended style.

In Assignment 2 (11 September 2007) the order of the lesson outcomes and the lesson plan made sense in terms of mathematical coherence and with respect to mathematical progression. Learners were asked to convert ratio to percentages and fractions; then to degrees for the drawing of a pie chart. Thereafter learners were required to draw the graphs, make comparisons and draw conclusions. The different mathematical topics were clustered together in a way that is mathematically coherent. Mathematical progression was also evident in the worksheet developed for Assignment 2 (11 September 2007). In question 2.1 the questions from question 2.1.1 to question 2.1.4 followed

mathematically coherently on each other. The questions also showed mathematical progression with respect to cognitive demand.

Mathematical progression with respect to mathematical content was also visible between the two written tasks mentioned above. The mathematical focus of the first set of written ideas linked to the calculation of the measures of central tendency and the presentation of data; the second worksheet included these two topics, but extended to also include ratio's and questions that interrogated the context to a larger extent. Whilst Teacher B's data showed some examples of mathematical errors, the errors were fewer than in Teacher A's case.

5.6.2.5 Mathematical Literacy and abstract mathematics

In Teacher B's Mathematical Literacy teaching practice the mathematics occasionally stayed abstract since the answers to the calculations could not always be linked back to the context, and therefore did not further unpack the given context. This was visible in the worksheet set for the planned lesson (Assignment 2, 11 September 2007). An example is Question 2.2 in Table 17). Learners were given a selection of the table of information and then asked the following:

2.2.1 Draw a compound bar graph based on the data contained in the table.

2.2.2 Based on the table in 2.2.1 calculate the:

2.2.2.1 Mean

2.2.2.2 Range

2.2.2.3 Median

Use only the percentages for men.

Learners were required to do the mathematical representation and the calculations, but the information gained was not linked back to the context again. In other examples (activity 5 and 7, Portfolio 1, 20 February 2007), the need for interpretation was incorporated.

In the next section Teacher B's teaching practice with respect to the relationship between context and mathematical content is discussed in more depth.

5.6.2.6 The relationship between mathematical content and context

Contextually sensitive selection of context

Teacher B appeared to work contextually sensitively when planning and presenting his Mathematical Literacy lesson. The choice of context that he engaged with in the written ideas (Portfolio 1, 20 February 2007) in Table 14, and the lesson plan and worksheet (Assignment 2, 11 September 2007) in Table 16 and Table 17, seemed to be chosen with a contextual and mathematical purpose in mind. The selection of context appeared to be contextually valid since the choice of context in the tasks was sensible and informed and unpacked the original contextual data further. Furthermore the choice of

context was mathematically coherent and served as a sensible vehicle choice to do the mathematics. The choice of context was largely done with respect to the following themes:

1. The rich (developed) and the poor (developing) countries in the world
2. The countries with the highest percentage of smokers
3. Gender

In Portfolio 1 (20 February 2007) he asked the learners to compare the averages of African and European male smokers. Learners then had to draw conclusions based on the comparisons of the two calculations. The geographical choice of context compared the rich and the poor countries and therefore made contextual sense. The choice also made mathematical sense since the averages had to be calculated to be able to do the comparison between the rich and the poor countries. In the planned lesson for Assignment 2 (11 September) and the presentation of the lesson (13 September 2007) the smokers' percentages of the (developing) African and (developed) G7 countries were noted and learners were asked to compare the data.

Teacher B's choice of G7 countries indicated a contextually sensible choice since learners were informed regarding the G7 countries. The G7 countries were described as the 'decision-making countries' and the purpose for the association of these countries within the world economy was flagged up. The selection of only seven countries reduced the repetitive procedural demands within the procedure, for example in relation to the number of data points that had to be added for the calculation of the mean. The choice of G7 countries also served a contextual purpose since it further explained the data given for the smoking context. Hence, Teacher B integrated pedagogical, mathematical and contextual rationales for the selection of the G7 context.

Learners were requested to identify the countries with the highest smokers' percentages and represent them on a bar graph (Portfolio 1, 20 February 2007; Assignment 2, 11 September). The choice to represent the 'high smoking countries' had contextual validity since it further informed the smoking context.

Teacher B's choice of context was frequently gender sensitive. In Portfolio 1 (20 February 2007) he asked learners to calculate the measures of central tendency for female and male smokers' percentages, compared percentages of African and European male smokers and requested learners to draw a pie chart for female African smokers' percentages and draw conclusions. In Assignment 2 (11 September 2007) the context chosen in the lesson plan was also sensitive to gender since learners were asked to represent the percentage of male and female smokers in a compound bar graph (lesson plan), calculate the percentage of Kenyan male smokers (worksheet, question 1.2.1) and calculate the measures of central tendency for men (worksheet, question 2.2.2).

However, the reasons for the choice of context were not always obvious. In the worksheet submitted for Assignment 2 (11 September 2007) the reason for the choice of countries preferred for question 2.2 and 3.1 was not clear and appeared to be fairly random.

On the whole, Teacher B kept the context in focus when selecting the data to do the mathematics. He then did the mathematics within the contextual frame set by the choice of context; in other words he used the context to act as a vehicle to do the mathematics, with some follow up interpretation.

Teacher B included geography in the general smoking context by referring to the location of the smokers' countries and the developing and developed countries. It might be noted that his prior training and experience as geography teacher might have positioned him to interpret the contextual data through geographical lenses.

The style of working with content and context

The lesson planning for the lessons using the smokers' data was mainly mathematical in nature (Questionnaire 1, 20 February 2007; Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007). Initially (Questionnaire 1, 20 February 2007) it seemed that Teacher B saw it as his responsibility as a teacher of Mathematical Literacy to teach the mathematics. In the Questionnaire 1 (20 February 2007), in particular, it can be noted that for him the choice seemed to be what mathematical topic he should teach, measures of central tendency or graphs. Teacher B gave preference to the mathematics and the context was the place where the mathematics was located and served as a vehicle to present and explain the mathematics.

In the lesson plans, assignments set for the lessons (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and lesson presentation (13 September 2007) it might be noted that the teacher worked mainly within the mathematics, occasionally moved towards the interrogation of the context and sometimes integrated answers to calculations with the context when he asked learners to 'draw conclusions' (Portfolio 1, 20 February 2007). The nature of the questions for the assignments were largely mathematical, using the context as a vehicle, but answers to the calculations were sometimes linked back to the context. There is therefore less separation of mathematics and context in Teacher B's tasks than in Teacher A's tasks. Furthermore, the contextually sensitive selection of context showed Teacher B attempted to develop a dialectical relationship between the elements of context and contents in his planning of the lesson.

As discussed in the previous section, Teacher B frequently referred to the use of the calculator in the teaching of Mathematical Literacy. Evidence for this is found in Portfolio 1 (20 February 2007), Portfolio 3 (13 March 2007) and the lesson presentation (13 September 2007). Teacher B's emphasis on the use of the calculator indicated his mathematical-orientated view regarding the nature of Mathematical Literacy. His statement that 'technology helps learners to investigate mathematical

ideas and finding solutions to mathematical problems' (Portfolio 3, 13 March 2007) indicated an inclination towards mathematical problem-solving. This view is also shared by Pugalee (1999).

It might therefore be noted that Teacher B thought in February 2007 that the teaching of Mathematical Literacy was mainly the teaching of mathematics and the context was used to do the mathematics. However, later, in Questionnaire 2 (October 2007), it appears that his thinking had changed regarding the importance of the inclusion of context, and he described Mathematical Literacy as he saw it at that moment compared to February 2007:

> It is different because I thought we were going to do mathematics and it's procedures to arrive at answers … before … I was teaching maths instead of Mathematical Literacy. At the beginning of the year I would only teach mean, median, tally, etc and not focusing on the interpretation of tables.

In the Interview (May 2008) Teacher B further explained how he understood Mathematical Literacy and how it had changed over time:

> In the beginning … I was just teaching mathematics. Mathematical Literacy is meant to apply the … mathematical knowledge … to the situations that they are faced with in real life. … Before I would have taught learners equations, … factorisation … In the beginning of the year …I would have focused on the mathematics directly; I would say how to draw a graph … Contexts enabled me to show learners how to plot graphs which is a mathematical content…..I was not directly teaching them graphs. In teaching the context they happen to learn about the mathematical content of graphs.

The above quotes in Questionnaire 2 (October 2007) and the Interview (May 2008), suggested that Teacher B previously understood Mathematical Literacy teaching to be similar to the teaching of mathematics, but later saw it as the basic application of mathematics to contextual situations that learners might be faced with. It might be noted that Teacher B's teaching indicated a context-orientated shift where the context seemed to be more emphasized than the content, therefore a shift away from the mathematics in the contextual direction.

The order of working with content and context

Teacher B largely worked within the mathematics and used the context as vehicle, but occasionally foregrounded the context as seen in the lesson planning and lesson presentation in Portfolio 1 (20 February 2007), Assignment 2 (11 September 2007) and Lesson presentation (13 September 2007). When planning and presenting the Mathematical Literacy lessons Teacher B initially worked within the mathematics and the focus fell on the development of mathematical skills. However, there appeared to be various shades of differences where the mathematics and the context were alternatively foregrounded.

In Questionnaire 2 (13 September 2007) it was noted that Teacher B suggested that the mathematics should be followed by application of the mathematics within a context when he described the teaching of Mathematical Literacy as follows:

> The content allowed me to unfold the context. I used the maths content to explain what the context was all about. The content made sure that the context became meaningful.

However, in the Interview (May 2008) Teacher B apparently changed his opinion regarding the order of working with the context and content. Teacher B indicated that the context should be chosen first and then the relevant mathematical content could be chosen in order to solve the contextual problem:

> Out of the context learners are able to draw graphs which enabled them to analyse the data provided in the context. The content must be chosen to solve the context. You just put the context before the content. You only resort to the content when you try to solve the context.

It can therefore be noted that Teacher B did not have a definite plan as to the order of teaching the components of context and contents when teaching Mathematical Literacy.

The relationship between content and context with respect to the spectrum of teaching agendas described by Graven and Venkat (2007).

As discussed in the previous section Teacher B initially saw the teaching of Mathematical Literacy mainly as the teaching of mathematics (Questionnaire 1, February 2007; Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007). The focus fell on the mathematics and the context was used largely as a vehicle for teaching and doing the mathematics. In the interview (May 2008) Teacher B saw himself as initially teaching mathematics in the Mathematical Literacy class when he said 'in the beginning … I was actually … just teaching mathematics'. This view could place Teacher B in the Content driven agenda as described by Graven and Venkat (2007) since he was teaching basic mathematics of the GET band. The mathematical aim of the lesson appeared to be more significant than the unpacking and the solving of the context.

As mentioned in the previous section, it appeared that Teacher B had changed his thoughts on Mathematical Literacy teaching and the relationship between content and context over time, since he suggested in Questionnaire 2 (13 September 2007) that the content be unpacked and used to explain the context.

The above statement is different from his previous statement earlier in 2007 when his focus fell mainly on doing the mathematics. Now Teacher B's focus emerged to be more contextual and it appeared as if he planned to teach Mathematical Literacy by connecting the elements of context and mathematical content in a Mathematical Literacy lesson. If he taught the way he appeared to see the relationship, it would have placed him in the Content and context driven agenda (Graven and Venkat, 2007). The Content and context driven agenda interprets the two components as interconnected, therefore in a dialectical relationship. However, Teacher B's teaching practice (Portfolio 1, 20

February 2007; Assignment 2, 11 September 2007; Lesson presentation, 13 September 2007) did not always support this view. In practice he focused more often on the mathematics or the context, but did largely not integrate the two components. Support for this statement follows.

The teaching ideas (Portfolio 1, 20 February 2007), lesson plan and worksheet (Assignment 2, 11 September 2007) and lesson presentation (13 September2007) were largely mathematical in nature and the smoking context was used as a vehicle to do the mathematics. He overtly attempted to link the mathematics back to the context and to interpret the mathematical calculations and representations when he asked for analyses and the drawing of conclusions (Portfolio 1, 20 February 2007 when planning the lessons, but he did not completely develop a dialectical relationship between the context and the content. As noted previously the mathematical calculations for the questions in the worksheet (Assignment 2, 11 September 2007) largely did not feed back into the context. Furthermore, in the lesson presented on 13 September 2007, Teacher B mainly worked within the mathematics and used the context as a vehicle to explain the mathematics, but kept the components separate.

Teacher B sometimes contributed to the authenticity of data, e.g. he provided the population figure for South Africa in question 1.2.2 in the worksheet for Assignment 2 (11 September 2007), but this was not done consistently. The 'authenticity of context was sacrificed so as to meet maths goals' (Graven and Venkat, 2007) in the same worksheet in question 1.2.4 since the question was not authentic with respect to the context of population growth since it does not allow for the escalation/change of the number of smokers per year. Compromising the authenticity of the context also occurred in the interview (May 2008) when Teacher B indicated: 'I just gave them statistics, but they were not real statistics.' The context was used as a vehicle for the mathematics; but the authenticity of the context was compromised.

The above analysis shows that Teacher B taught Mathematical Literacy in the Mainly content driven agenda (agenda 3) as described by Graven and Venkat (2007). His teaching differed slightly from this approach since the agenda proposes that learners are given the opportunity to 'to learn maths and then to apply it to various contexts', but Teacher B started with the context and followed it with the teaching of mathematics. He used the context as a vehicle to give learners an opportunity 'to learn maths and then to apply it to various contexts' (Graven and Venkat, 2007). His 'teaching focuses on mathematical learning and its use in applications and doesn't necessarily require much discussion of context' (Graven and Venkat, 2007). Furthermore, authenticity of context did not appear to be consistently important to him and it was often 'sacrificed so as to meet maths goals' (Graven and Venkat, 2007).

5.6.2.7 **The use of technology**

Teacher B made frequent reference to the use of technology in the empirical data. He referred to the importance of the computer, more specifically the internet, in his own learning, referring to accessing information on wikibooks (Portfolio 1, 20 February 2007).

In Portfolio 3 (13 March 2007) Teacher B also emphasized a technology-orientated view when he described Mathematical Literacy with a definite reference to the use of technology:

> It (Mathematical Literacy) gives learners confidence in dealing with technology (computers and calculators). Technology helps learners to investigate mathematical ideas and finding solutions to mathematical problems.

He further claimed that the use of calculators could lead to cognitive development since he stated that the use of calculators encouraged the development of higher order thinking (Portfolio 3, 13 March 2007) and that Mathematical Literacy was 'also aimed at developing higher order thinking amongst learners'. According to Pugalee (1999) the use of the calculator in teaching Mathematical Literacy acts as an enabler of the processes of 'doing mathematics' and can enhance mathematical thinking, a view Teacher B appeared to support. For example, he chose calculators as a possible resource for the planned lesson in Portfolio 1 (20 February 2007) and asked the learners to 'press your calculator' when calculating the degrees of a pie chart sector that represented a certain smokers' percentage in the lesson presentation (13 September 2007).

The use of technology is in line with the official policy as stated by the Department of Education's NCS for Mathematical Literacy policy document (DoE, 2003a).

In the next section Teacher B's view on Mathematical Literacy teaching and the ethical and moral aspects with respect to the practice of smoking which emerged in Teacher A's analysis is considered.

5.6.2.8 **Ethical and moral values**

Teacher B's opinion

Teacher B's personal view on the practice of smoking was evident when he pointed out that 'countries of the world are fighting the war against smoking' (Portfolio 1, 20 February 2007) and later 'winning the war against smoking' (Assignment 2, 11 September 2007). The choice of the word 'war' indicates a negative perception regarding smoking. In so doing he disclosed a moral opinion with respect to smoking and conveyed a value perspective to the learners. He did not allow for a classroom discussion regarding the practice of smoking where the learners were able to construct their own opinions. These statements indicated a judgemental opinion regarding smoking which might have influenced the learners engaged in the task.

In the introduction of the lesson presentation (13 September 2007) Teacher B repeated a value perspective with respect to smoking as a 'problematic' habit:

> You know we have this problem of smoking. Unfortunately we have our country South Africa stated there.

In the informal interview (May 2008) Teacher B was asked to give his views on ethical and moral value discussions in the classroom. It is evident from the interview that Teacher B felt very negative about the practice of smoking. As with Teacher A, he saw it as his pedagogic responsibility (Tuana, 2007, p2) as a teacher to share his opinion regarding the practice of smoking with his learners in order to prevent the learners from smoking when he stated 'now for them to stop smoking we need to teach them at school'. Unlike Teacher A though, he referred to the fact that the learners might disagree with his view when he said (Interview, May 2008):

> Some people will differ with you. Not all the learners will support what you are saying.

In the lesson presentation (13 September 2007) Teacher B conveyed a value opinion regarding the economic decision-making practice where developing countries were 'sponsored and controlled' by the developed countries. He stated his opinion with respect to this practice as follows:

> The G7 countries are the ones that control the economy of the world. We listen to them. Even in South Africa we listen to them. They make decisions. Economic decisions on behalf of the whole world because they are able to sponsor some countries.

Other contexts with value-orientated views

In the interview (May 2008) Teacher B was requested to make suggestions regarding contexts where a teacher should share his/her opinion with the class. He mentioned the topics of teenage pregnancy and finances. He said that after investigating statistics about teenage pregnancy learners engaged in class discussions about it. Furthermore, he suggested a teacher has the responsibility to teach learners how to manage their personal finances:

> We need to start teaching our learners the right budget so that when they grow up they shouldn't be like us.

The view of pedagogic responsibility of the teacher is also shared with Tuana (2007, p2).

How to share ethical and moral contexts in the class

Teacher B indicated in the interview (May 2008) that he preferred to open a topic and allow for class discussion where learners share their views with each other and with the teacher:

> You bring it (the topic) as a lesson in the class and then you get their feelings. But you just direct them. They give you their feelings. ... Then they come up with ideas. And you add your own ideas. ... Not all the learners will support what you are saying. Some of them might be supporting you because you are an adult, but you look at their responses…. you give them a chance to express their views, but you guide their views. And the decision will come from the class. Because if you come and impose your opinion on the class you become the source of information. You go back to the type of teaching we are coming from (where) the teacher has the information and there is no information that will come from the learners.

Teacher B indicated that the role of the teacher is to act as a facilitator who opens up contextual discussion. This would enable learners to have the opportunity to construct their own opinions after investigating other views and facts. Teacher B suggested that the teacher should urge the learners to share their opinions. In practice, however, he did not give learners the opportunity for class discussion with respect to the issue of smoking. The reason for this could be that more time was given in his lesson to developing mathematics than contextual discussion, including ethical and moral discussion. Ethical discussion and the development of moral opinions/stances were less emphasized by Teacher B than by Teacher A.

The view on discussion of ethical issues is also hold by Tuana (2007) since she states that learners should judge whether a situation is ethically sensitive (p2), weigh it within the communal context of beliefs and values (p3) and then 'assess the validity of facts' within the context. The identification and assessment of facts is referred to as ethical reasoning (Tuana, 2007, p3). Teacher B included the element of ethics sensitivity in his classroom practice since he conveyed a clear opinion with respect to the practice of smoking, however to a lesser degree than Teacher A. Teacher B planned to include ethical reasoning as part of his lesson practice since he stated that a teacher and learners should bring in feelings, ideas, views and statistics (facts), and reason about, analyse and interpret a given contextual situation. However, in practice his teaching was focused on the teaching of mathematics without an ethical dimension.

In chapter 6 I present a cross-analysis discussion with respect to the two case studies. The analysis includes commentary on direction and shifts across the two case studies. The findings that came out of the analysis is followed by a reflection on the analysis, recommendations based on the research, and suggestions on the way forward with respect to further research questions.

6 Conclusion

In the previous chapter the stories of Teacher A and Teacher B were shared, discussed and analysed. In this chapter I look across the two case studies and analyse similarities, differences and shifts over time within and between the case studies in order to investigate the meaning and teaching practice (Wenger, 1998) of Mathematical Literacy, in particular with respect to the relationship between context and mathematical content. I discuss the following:

1. The findings that follow from the analysis with respect to:
    - Teacher understanding of the nature and purpose of Mathematical Literacy
    - Mathematical Literacy teaching practice
2. Reflections and recommendations that follow from the analysis with respect to:
    - Mathematical Literacy teaching practice
    - ACE Mathematical Literacy course
    - Mathematical Literacy teacher training
3. The way forward

6.1 Findings

The section refers to findings within the analysis and includes the following themes:

1. Teacher understanding of the nature and purpose of Mathematical Literacy
2. Mathematical Literacy teaching practice

6.1.1 Teacher understanding of the nature and purpose of Mathematical Literacy

Both Teacher A and Teacher B engaged to a significant degree with referencing and restating of the policy documents on Mathematical Literacy and seldom shared their own voices. The NCS for Mathematical Literacy (DoE, 2003a), in particular, and other course readings were quoted by the teachers throughout the research period. The course readings included articles of Steen (2001) and Pugalee (1999) and curriculum guidelines on the teaching of Mathematical Literacy (DoE, 2003a; DoE, 2005; DoE, 2008; DoE, 2006). Teacher A, in particular, appeared to do heavier referencing of the curriculum documents and articles than Teacher B.

Teacher A shared a personal voice when she linked Mathematical Literacy to the financial context, statistics, the workplace and real life (Portfolio 1, 20 February 2007; Questionnaire 1, 20 February 2007; Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007; DoE, 2003a; Steen, 2001). Teacher B revealed more of his own voice than Teacher A when he connected Mathematical Literacy to the communication of information, statistics (Portfolio 1, 20 February 2007; Questionnaire 1, 20 February 2007; Portfolio 3, 13 March 2007; DoE, 2003a; Steen 2001), the raising of numeracy levels and more possibilities for tertiary education, therefore also for better career opportunities (Portfolio 3, 13 March

2007). Therefore, Teacher A and Teacher B focused on the same aspects of Mathematical Literacy of preparing learners for life after school, but in different ways. The occasional sharing of their own voice suggests reluctance to take ownership of the nature and purpose of Mathematical Literacy. There is a sense of what they see as 'appropriate answers' with respect to the questions asked on the nature of Mathematical Literacy, since the answers were largely based on the course readings rather than experience and may well be a consequence of the way the course was presented and the fact that I was both course assessor and researcher.

Both Teacher A and Teacher B acknowledged the role of mathematics and saw mathematics as a tool for the understanding and solving of contexts when teaching Mathematical Literacy. Furthermore, both teachers indicated that mathematical content and context were key components of Mathematical Literacy teaching.

It might be noted that the training and experience of each teacher seemed to position him/her differently with respect to the other teachers' views on the smoking amongst adults' data. Each teacher drew on his/her own individual training and experience when dealing with the context proposed to him/her. Teacher A and Teacher B drew on her/his prior knowledge and experience with respect to life sciences and geography respectively. Historical knowledge and teacher identities (Wenger, 1998) therefore appeared to influence Mathematical Literacy teaching practice.

The teachers showed overlap in the meaning (Wenger, 1998) of Mathematical Literacy, but also differences in emphasis and direction of change in the understanding of the nature and purpose of the subject and how it should be taught, over time. The next section focuses on the teaching practice of Mathematical Literacy.

6.1.2 Mathematical Literacy teaching practice

It appears that both ACE Mathematical Literacy teachers showed a good scholarly understanding of the nature and purpose of Mathematical Literacy. However, it appears that the teachers have assimilated, accommodated and interpreted the Mathematical Literacy knowledge and meaning in different ways when they developed their Mathematical Literacy teaching practice (Wenger, 1998). The similarities, differences and shifts (over time) of the teachers' Mathematical Literacy classroom practice are discussed under the following headings:

1. Assessment of Mathematical Literacy
2. Mathematical coherence, progression and scaffolding
3. Mathematical Literacy and abstract mathematics
4. The relationship between mathematical content and context
5. The use of technology
6. Ethical and moral values discussions in the Mathematical Literacy classroom
7. Relation to Wenger's framework of Learning

6.1.2.1 **Assessment of Mathematical Literacy**

6.1.2.1.1 The types of questions asked in relation to context and content

Teacher A and Teacher B included mathematical and contextual questions in the worksheets they provided to the learners, but the focus was mainly on the inclusion of mathematical questions. The mathematical and contextual questions were largely not linked, but kept separate. Teacher B seemed to do more linking between the context and content (Teaching ideas, Portfolio 1, 20 February 2007) than Teacher A when he asked learners to 'draw conclusions'. Teacher A provided no evidence to show that the answers to the mathematical calculations fed back into the context, or vice versa. It might be noted that the mathematical questions largely used the context as a vehicle to locate the mathematics. Teacher A used the general smoking context as a vehicle to do the mathematics. Teacher B's choice of specific context focused more on contextual features with respect to the differences in smoking trends within and between countries.

The spectrum of Mathematical Literacy teaching agendas (Graven and Venkat, 2007) that was used as an analytical tool to analyse teacher practice provided a useful framework to classify the types of questions Mathematical Literacy teachers could include in classroom assessment tasks. The frame that emerged from the analysis of the teachers' data on assessment tasks led to a classification that included five categories of questions. The categories, similar to the spectrum of agendas (Graven and Venkat, 2007), strongly linked to Mathematical Literacy teachers' interpretation of the relationship between context and content. The categories, which will be described in more detail later in the chapter, are the following:

1. Contextual questions
2. Contextual questions where the mathematics is in service of the context
3. Dialectical questions
4. Mathematical questions where the context is in service of the mathematics
5. Mathematical questions

The data for the analysis was obtained from the activity (Teacher A) or teaching ideas (Teacher B) in Portfolio 1 (20 February 2007), and worksheets for Assignment 2 (11 September 2007) for Teacher A and Teacher B. The assumption was made that the percentage weighting for the assessment tasks for Portfolio 1 (20 February 2007) and Assignment 2 (11 September 2007) were equal.

According to the analysis of the types of questions set by Teacher A and Teacher B, questions could either be classified as contextual questions or mathematical questions where the context is in service of the mathematics, in other words where the context is used as a vehicle to do the mathematics. No evidence of contextual questions where the mathematics is in service of the context, dialectical questions or pure mathematical questions in the assessments tasks was noted. Table 21 supplies a

summary of the types and percentage of questions included by Teacher A and Teacher B in assessment tasks.

The analysis showed Teacher A included 81.5% and Teacher B 85.5% mathematical questions where the context is used as a vehicle to do the mathematics in the activity, teaching ideas or worksheets used for data collection. Furthermore, Teacher A included 18.5% and Teacher B 14.5% contextual questions where no reference was made to the mathematics in the assessment tasks. On average, in Table 21, 83.5% of the questions asked in the assessment tasks were mathematical questions where the context is in service of the mathematics, and therefore the questions that both the ACE Mathematical Literacy teachers included in their tasks could largely be described as mathematical. On average, 16.5% of the questions could be described as contextual questions.

Category	**Percentage of questions per category**			
Types of questions	**Teacher A**		**Teacher B**	
	Portfolio 1	Assign. 2	Portfolio 1	Assign. 2
Contextual questions	20%	17%	22%	7%
	18.5%		14.5%	
Contextual questions where the mathematics is in service of the context	0%	0%	0%	0%
Dialectical questions	0%	0%	0%	0%
Mathematical questions where the context is in service of the mathematics	80%	83%	78%	93%
	81.5%		85.5%	
Mathematical questions	0%	0%	0%	0%

Table 21 Description of the types of questions in the research analysis

The evidence presented in Table 21 shows limited practical growth in the design of a Mathematical Literacy assessment task if Teacher A' and Teacher B's classroom tasks for Portfolio 1 (20 February 2007) were compared to the worksheet that they supplied as part of Assignment 2 (11 September 2007). The questions included in the assessment tasks indicated shifts between a contextual focus and a mathematical orientation. Interesting to note is that Teacher A indicated a movement in a

mathematical direction with respect to her meaning of Mathematical Literacy over time, and this view was confirmed in the types of questions included in her tasks over time since the percentage of mathematical questions was slightly higher for the second assessment task than for the first task. Teacher B's view on Mathematical Literacy changed from a mathematical focus to a more context-orientated view, however the percentage of mathematical-oriented questions compared to the percentage of contextual questions, increased over time.

Graven and Venkat (2007) do not make specific reference to different types of questions that can be asked in assessment tasks, but I found this framework useful for analyzing the range of questions that were asked (or can be asked) related to my extended spectrum of Mathematical Literacy teaching agendas – as will be discussed later in this chapter.

The cognitive level of questions

The proposed framework for the assessment of Mathematical Literacy is summarized in Table 3 (DoE, 2008, p 27-28). According to the Subject Assessment Guidelines (DoE, 2008), assessment should be set at different levels of cognitive demand. Assessment should include lower cognitive demand tasks that require simple reproduction of facts and information, but also high level cognitive demand tasks that require 'detailed analysis and the use of varied and complex methods and approaches' (DoE, 2008, p8; Venkat and Phungula, 2008). It was noted in the discussion in chapter 3 that the Department of Education's assessment framework for Mathematical Literacy (DoE, 2008, p8) suggests that 'reasoning and reflective' questions are higher-order questions. However, Steen (2001) and Venkat et al. (2009) argue that reasoning is needed on all levels of questions. Venkat et al. (2009) suggest the inclusion of low and high(er) level reflective questions used in Mathematical Literacy teaching practice.

The teachers were not asked to set the first activity or teaching ideas for Portfolio 1 (20 February 2007) according to the allocation per cognitive level for examination tasks as prescribed by the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008), thus they had the freedom to include questions on the cognitive level of their choice. In September 2007 teachers were asked that 40% of the questions for the worksheet (Assignment 2, 11 September 2007) should require learners to perform multistep procedures and to reason and reflect on their work.

I analysed the assessment tasks of Teacher A and Teacher B according to the cognitive level and classification of questions (Table 3) following the Mathematical Literacy assessment taxonomy (DoE, 2008), but added an additional description of a task as a low-level reflective question (LLR). It was interesting to note that both teachers included low-level reflective questions, but no 'reasoning and reflecting' questions as defined by the curriculum documents (DoE, 2008). The analysis for Teacher A and Teacher B is summarized in Table 22:

Task	Teacher A					Teacher B				
Cognitive level of question	**L1**	**L2**	**L3**	**L4**	**LLR**	**L1**	**L2**	**L3**	**L4**	**LLR**
Activity: Portfolio 1	60%	20%	0%	0%	20%	45%	22%	11%	0%	22%
Worksheet:Assignment 2	47%	40%	0%	0%	13%	28%	53%	11%	0%	8%
Average %	53.5%	30%	0%	0%	16.5%	36.5%	37.5%	11%	0%	15%

Table 22 Classification of questions according to cognitive level

In Table 22 the percentage allocation per level for Portfolio 1 (20 February 2007) was done with respect to the number of questions in the assessment task since the teachers did not allocate marks for the questions asked. In Assignment 2 (11 September 2007) the percentage allocation per level was done with respect to the mark allocation per question in the worksheet.

Overall, the cognitive level of questions for the tasks analysed appeared to be higher for Teacher B than for Teacher A. Teacher A included no 'applying multistep procedures in a variety of contexts' (level 3) or 'reasoning and reflecting' questions (level 4) in either of the two assessment tasks. Teacher B included no 'reasoning and reflecting' questions (level 4) in the assessment tasks that he submitted. Furthermore, on average, Teacher B included a smaller percentage low level reflection questions in the tasks than Teacher A.

The analysed tasks will largely prepare learners for Paper 1 of the National Senior Certificate examination, and mainly not for Paper 2 (DoE, 2008; Venkat and Phungula, 2008). This suggests that 'learning' in relation to design and use of tasks for Mathematical Literacy has not been well communicated in the ACE Mathematical Literacy course.

6.1.2.2 Mathematical coherence, progression and pedagogical scaffolding

Teacher B appeared to largely plan and set tasks in a mathematically coherent style, with evidence of scaffolding. Mathematical progression was observed within and across the written teaching ideas for Portfolio 1 (20 February 2007) and the worksheet set for Assignment 2 (11 September 2007). The data collected for Teacher B indicated various examples of where he planned to scaffold concepts or practically support learners in the classroom through reducing contextual scope (Portfolio 1, 20 February 2007; Questionnaire 1, 20 February 2007; Assignment 2, 11 September 2007; Lesson presentation, 2 October 2007). In the lesson plan (Assignment 2, 11 September 2007) he reflected that more time might be needed for teaching the content. Teacher B showed pedagogical awareness and it might be noted that he expected learners not to have all the prior mathematical knowledge of grade 9 mathematics. He anticipated that he would have to scaffold learners which might include re-teaching of certain mathematic topics.

Teacher A, on the other hand, did not always follow a mathematically coherent approach. Several examples included language used to describe a mathematical task as not clear and coherent, with her answers not providing understanding of the context or the embedded mathematics for the learners. Furthermore, the data for Teacher A showed less evidence of scaffolding.

6.1.2.3 Mathematical Literacy and abstract mathematics

An important aspect of the Department of Education's view on the teaching of Mathematical Literacy is to use the mathematics to make sense of real-life situations or contexts (DoE, 2003a; Steen, 2001). The mathematics, or the answers to the calculations, should therefore not stay abstract, but should be linked back to the context to make sense of the real-life situation.

Steen (2001) sees the teaching of quantitative literacy as staying within the context and accessing the relevant mathematics to solve the contextual problem in order to explain and unpack the context. The contextual data can be described as authentic in nature (Steen, 2001). Quantitative literacy is different from mathematics and could be described as an approach to solving real-life problems.

Teacher A and Teacher B worked within a contextual frame and then followed it with some mathematical calculations. Teacher A, more than Teacher B, failed to consistently relate the mathematical answers back to the context again in order to make sense of the real-life situation. The contents and the contexts remained mainly separate and therefore the Mathematical Literacy teaching seemed to incorporate a level of abstraction. Teacher A saw Mathematical Literacy as more abstract than Teacher B since she kept the context and the 'doing mathematics' more separate than Teacher B.

Christiansen (2006, p10) also shares a view that Mathematical Literacy is mathematical, and hence has a level of abstraction. Teacher A and Teacher B's Mathematical Literacy teaching practices and the view of Christiansen (2006) indicate a higher level of abstraction than the proposed teaching approach provided by the curriculum documents (DoE, 2003a; DoE, 2008; DoE, 2006) and Steen (2001).

6.1.2.4 The relationship between mathematical content and context

Teacher A and Teacher B both indicated throughout the 16 months of the research study that context and mathematical contents were both important components of a Mathematical Literacy lesson. This view is also held by Steen (2001), Pugalee (1999), Ellis (2001) and the NCS for Mathematical Literacy (2003a).

Teacher A shared her own voice regarding the choice of context when she stated that if the context was familiar and interesting to the learners, the learners would be interested in the Mathematical Literacy lesson and in the process engage more with the mathematics (Steen, 2001, p16). The NCS (2003a, p43) and Boaler (1997) claim that doing mathematics within a contextual framework makes the understanding of the mathematics better. Teacher A worked with the context in two separate ways.

She investigated the general smoking context within a context-orientated teaching approach and linked it to ethical sensitivity, however not including elements of ethical reasoning or moral imagination (Tuana, 2007) with regard to facts relevant to the ethical situation of smoking. Secondly she used the contextual data as a vehicle to do the mathematics.

Teacher B appeared to work contextually sensitively with the context given for the Mathematical Literacy lesson. He preferred to work within a specific context, not the general context on the practice of smoking. Teacher B's selections of context for the mathematics tasks overtly had some contextual validity and were at times chosen with contextual purpose, for example when he investigated data for the countries with the highest percentage smoking rate, contrasted data for developed and developing countries, or was gender sensitive. Occasionally his choice of context seemed to be done with a mathematical or a pedagogical purpose (choice of G7 countries) in mind. Teacher B, similar to Teacher A, used the context largely as a vehicle to do the mathematics.

Teacher A worked within a context orientation followed by a mathematical content section - the mathematical activity (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007; Lesson presentation, 2 October 2007). She did extensive discussion of the general smoking context, focusing on moral issues with respect to the practice of smoking, but without inclusion of the mathematics. Thereafter, the context was used as a vehicle to do the mathematics, but answers to the calculations did not deepen contextual understanding. She kept the context and the contents separate in the lesson plan and presentation. Of interest in relation to this practice is that her view with respect to the meaning and emphasis in a Mathematical Literacy lesson changed over time from a contextual orientation to a more mathematical approach.

Teacher B initially (Portfolio 1, 20 February 2007; Questionnaire, 20 February 2007) gave preference to the teaching of mathematical content using specific contexts in his teaching ideas. The mathematics and contexts was largely kept separate, although there was some evidence of a link between the mathematics and the context when he asked learners to draw conclusions from calculations. In Assignment 2 (11 September 2007) he appeared to be more context-orientated in his lesson planning than in February 2007. In the interview in October 2007 it appeared as if Teacher B's thoughts had changed regarding the importance of the inclusion of context; he shifted from a mainly mathematical orientation in a direction where the context played an increasing role. In practice he kept the components of context and content less separate than Teacher A.

Teacher A and Teacher B did not suggest a definite order in which the two components of contents and context should be presented in the classroom. Both teachers' comments suggested that they would sometimes work from decontextualised content into applications, and sometimes from the context into the mathematics when teaching Mathematical Literacy.

To summarise: From the above descriptions for Teacher A and Teacher B it could be noted that both teachers acknowledged the need for context and mathematical content in a Mathematical Literacy lesson. However, definite nuances in terms of the importance of the context and the mathematical content were notable. Teacher A worked from a general smoking context-orientation and, over time, brought in more mathematics. Teacher B worked differently: he started with the mathematics, used specific contexts to do the mathematics and showed some contextual integration. Over time, Teacher B brought in more contextual sensitivity in his lesson planning, although his later assessment task (worksheet) included a greater percentage of mathematical questions and indicated less contextual integration than his earlier teaching ideas.

In theory both ACE teachers recognized the need for the integration of content and context. In practice the teachers did not manage to integrate the context and the mathematical content and develop a dialectical relationship (DoE, 2003a; Graven and Venkat, 2007) between the components when planning and teaching the lessons.

The Department of Education describes its interpretation of the relationship between context and mathematical content in the curriculum policy document (DoE, 2003a) and guideline documents (DoE, 2008; DoE, 2005; DoE, 2006). As pointed out in chapter 3, Venkatakrishnan and Graven (2006) state that: 'there are mixed messages within the Department of Education's documentation for Mathematical Literacy' (p20). The space for interpretation of the curriculum documents was exemplified in this study in different teaching approaches with respect to the teaching of Mathematical Literacy. The spectrum of teaching agendas developed by Graven and Venkat (2007) was used as an analytical tool to classify the ACE Mathematical Literacy teachers' teaching practices in one of the four teaching agendas (Graven and Venkat, 2007). This task was not easy and straightforward.

Teacher A worked partially within the Context driven agenda and the Mainly content driven agenda described by Graven and Venkat (2007). The Context driven agenda focuses on 'increased discussion of the contexts … and the mathematics embedded in them', thus the mathematics stands in service of the context. Teacher A engaged with the general smoking context and focused on moral issues with respect to smoking, but the contextual discussion did not lead to engagement with the embedded mathematics. When moving into the mathematics she used the contextual data merely as a vehicle for the mathematics. The driving agenda for the Mainly content driven agenda is portrayed as the agenda 'to learn maths and then to apply it to various contexts'. Teacher A reversed the order suggested by the Mainly content driven agenda since she first engaged with the context, and then used the mathematics known to the learners and applied it to the contexts. Therefore she did not teach the mathematics, but applied selected mathematics to the contextual data. Teacher A did not link the answers back to the context, but kept the components of content and context separate.

According to the interview in May 2008 Teacher B initially planned to teach basic GET maths in the Mathematical Literacy classroom. This view indicated a mathematical goal to be more significant than the unpacking and the solving of the context and placed his planned teaching in the Content driven agenda as described by Graven and Venkat (2007). Teacher B's teaching ideas (Portfolio 1, 20 February 2007) and later lesson plan (Assignment 2, September 2007) and actual teaching practice (Lesson presentation, 13 September 2007) largely placed him in an adapted version of the Mainly content driven agenda (Graven and Venkat, 2007). The agenda asks for 'mathematical learning and its use in applications', in other words doing mathematics and then applying the maths in the contexts, but Teacher B, similar to Teacher A, started with the context, and then moved on to do the mathematics teaching within specific chosen contexts. There was some evidence of integration of answers in context (Portfolio 1, 20 February 2007), but on the whole he kept the context and content separate. Teacher B did not use the answers to understand or unpack the context further since answers to calculations were largely not linked back the context. Furthermore, Teacher B's teaching practice, similar to the Mainly content driven agenda (Graven and Venkat, 2007), did not 'necessarily require much discussion of context'. In addition, authenticity of context appeared to not to be centrally important to him even though he made efforts to incorporate some authentic information.

The analysis of the teaching practice of Teacher A and Teacher B suggested the possible need for the development of another agenda and an adaptation of the Mainly content driven agenda (Graven and Venkat (2007). This suggestion will be discussed in the later section on reflections and recommendations.

6.1.2.5 The use of technology

The use of technology in the Mathematical Literacy classroom is recommended by the NCS for Mathematical Literacy (DoE, 2003a). Furthermore Pugalee (1999) sees the use of technology as an enabler of the processes of 'doing mathematics' in the Mathematical Literacy classroom.

Teacher B frequently made reference to the use of technology, specifically the calculator, in the Mathematical Literacy classroom (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007; Lesson presentation, 13 September 2007). Teacher A, on the other hand, did not emphasize the use of the calculator. She did not refer to the use of technology in Portfolio 1 (20 February 2007), but there was also no indication that the calculations might require calculator work. In the lesson plan (Assignment 2, 11 September 2007) she indicated the use of the calculator as a possible resource when planning the lesson. However, in the actual lesson presentation (2 October 2007), the use of the calculator was not promoted.

6.1.2.6 Ethical and moral values discussions in the Mathematical Literacy classroom

Moral literacy (Tuana, 2007) is an important aspect of the education of learners. This view is underlined by the NCS for Mathematical Literacy (DoE, 2003a) since it states that 'values and

morality give meaning to individual and social relationships' (DoE, 2003a, p4). The issues of ethics sensitivity, ethical reasoning and moral imagination (Tuana, 2007) are referred to in the analysis of the two ACE Mathematical Literacy teachers. Teacher A referred to value and moral issues with respect to the practice of smoking in her planning and teaching practice to a larger extent than Teacher B. Both ACE Mathematical Literacy teachers saw their role as a teacher to be important with respect to moral issues and anticipated that their intervention might have an impact on the learners.

Teacher A's lesson planning (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) seemed to hold an open-minded, objective opinion regarding the habit of smoking, although her strong anti-smoking view was strongly reflected though out. In her teaching practice (Lesson presentation, 2 October 2007) the teacher created room for whole class discussion on the topic of smoking, although she shared an anti-smoking view. In class discussion Teacher A promoted ethics sensitivity (Tuana, 2007) since she probed learners to develop an ethical awareness with respect to the practice of smoking. The class discussion did not lead to ethical reasoning (Tuana, 2007) since learners did not reason about the facts and values relevant to the smoking situation. Furthermore, the element of moral imagination (Tuana, 2007) was only partially developed since class discussion did not show evidence of reasoning. Teacher A's ethical stance seemed not to figure strongly in the questions learners were given, so Table 12 and Table 21 did not have to incorporate an ethical dimension with respect to the types of questions.

For Teacher B the theme of ethics and moral values did not emerge spontaneously from the research data. It might be noted that he indicated an anti-smoking stance (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007; Lesson presentation, 13 September 2007) and therefore created ethical sensitivity (Tuana, 2007) towards the practice of smoking. The smoking issue and Teacher B's thoughts on smoking was purposefully flagged up in the informal Interview (May 2008). Teacher B claimed that he preferred to allow for class discussion where learners shared their views and that the teacher should act as facilitator for the class discussion (Interview, May 2008), therefore that the learners would then have the opportunity to construct their own opinions. Teacher B indicated that ethical reasoning where the facts were weighted, analysed and interpreted was the teaching practice he preferred. In practice (Lesson presentation, 13 September 2007), however, when planning and teaching the smokers' context, Teacher B did not give learners the opportunity for class discussion and reasoning about the practice of smoking since his focus was more on teaching mathematics.

Teacher A identified other contexts where she had taken a personal stance namely the context of shopping and budgets (Interview, May 2008). In the presentation of his lesson (2 October 2007) Teacher B communicated a position when he pointed out the practice where developing countries were 'sponsored' by the rich developed countries. This conveyed a specific value stance with respect to this practice between developing and developed countries. In the interview (May 2008) Teacher B

also mentioned the context of teenage pregnancy and personal finances as contexts where a teacher should share his/her opinion with the class.

The teaching agendas (Graven and Venkat, 2007) make reference to discussion of the context, but do not specifically refer to moral or ethical discussions with respect to the contexts investigated.

6.1.2.7 **Relation to Wenger's framework of Learning**

As discussed in chapter 2 the focus of this study is on Wenger's (1998) learning components of meaning and practice. In the context of the research the learning component of meaning might be explained as an understanding and experience of the new Mathematical Literacy curriculum as meaningful, and might include talk about ways of teaching the curriculum. According to Wenger (1998) the learning component of meaning connects to the component of practice, and therefore the understanding of the Mathematical Literacy curriculum and its outcomes as meaningful will lead to the formation of a classroom practice, or change an existing practice. Furthermore, reflection on teaching practice might, in turn, lead to a changed understanding of the meaning of the curriculum since the learning components 'mutually define' each other (Wenger, 1998).

The ACE Mathematical Literacy teachers shared general understandings of the nature and purpose of Mathematical Literacy and how it should be taught. Evidence suggested that the teachers' meanings relating to the nature and purpose of Mathematical Literacy were located within ACE Mathematical Literacy coursework and course readings. The component of meaning (Wenger, 1998) developed largely within the community of practice of the ACE Mathematical Literacy classroom. The sense of academic awareness and learning gained with respect to meaning was reflected largely in Teacher A' and Teacher B's identities as students of the ACE Mathematical Literacy course. This was visible in the formal written assignments (Portfolio 1, 20 February 2007; Portfolio 3, 13 March 2007; Assignment 1, 10 April 2007; Assignment 2, 11 September 2007).

The empirical data for this study suggested that the ACE Mathematical Literacy teachers' acquired meanings did not straightforwardly translate into a teaching practice I expected as part of the ACE Mathematical Literacy course. When asked to design Mathematical Literacy lesson plans, written activities and worksheets (Portfolio 1, 20 February 2007; Assignment 2, 11 September 2007) and teach the Mathematical Literacy lesson (Lesson presentation; 13 September 2007 and 2 October 2007), discontinuities emerged between the practice expected from the teachers as part of the ACE Mathematical Literacy course expectations and the actual teaching practice of the teachers. In the context of the ACE Mathematical Literacy course it was expected that the teachers would strive to develop a dialectical relationship (DoE, 2003a; Graven and Venkat, 2007) with respect to the context and the embedded mathematical content when planning and teaching the lessons. However, this was not the case since Teacher A and Teacher B engaged with both the context and the mathematics, but largely kept the two components separate since the answers to the calculations did mostly not feed

back into the solving of the context (Teacher A more than Teacher B). The learning component of meaning appeared to impact on the teachers' inclusion of context and content in the lesson plans, but integration of the components did not develop in practice since the context was predominantly used as a vehicle to 'do the mathematics'.

The teachers' own Mathematical Literacy classroom was also seen as a community of practice where the teacher's learning and his/her own acquired meaning of Mathematical Literacy translated into his/her own individual teaching practice during the lesson planning and presentations. The view of different interpretations with respect to Mathematical Literacy teaching practice, as observed within the empirical data for this study, is shared in the spectrum of teaching agendas (Graven and Venkat, 2007). As discussed in the previous section, Teacher A's teaching practice partially fitted in with the Context driven agenda and the Mainly content driven agenda. Teacher B's teaching practice fitted closest to the Mainly content driven agenda. Both ACE teachers did not seem to have developed a consistent teaching practice with respect to how Mathematical Literacy should be taught in the classroom.

6.2 Reflections and recommendations that follow from the analysis

There are significant outcomes that follow from the above analytical discussion. The findings and recommendations are discussed under the following headings:

1. Mathematical Literacy teaching practice
2. The ACE Mathematical Literacy course
3. Mathematical Literacy teaching and learning

6.2.1 Mathematical Literacy teaching practice

One of the aims of this study was to search across the empirical data for areas of 'relatability' (Opie, 2004) between the case studies. Findings and recommendations are pointed out with respect to assessment, in particular the types and cognitive levels of questions, the spectrum of Mathematical Literacy teaching agendas developed by Graven and Venkat (2007) and ethical and moral value discussions in the Mathematical Literacy classroom.

6.2.1.1 Assessment

The classification of the types of Mathematical Literacy questions

As pointed out earlier in the chapter and referred to in Table 21, the empirical data and the use of the spectrum of Mathematical Literacy teaching agendas (Graven and Venkat, 2007) led to an analytical frame that could be used for thinking about types of Mathematical Literacy questions. The frame presents a classification that includes five categories of questions that relate to Mathematical Literacy teachers' interpretation of the relationship between context and content. The categories and description of the categories are the following:

1. Contextual questions

   These questions are purely contextual questions with the focus on the investigation of the context. No reference is made to the mathematics; the mathematics is not in service of context. These questions are not included in the spectrum of teaching agendas (Graven and Venkat, 2007)

2. Contextual questions where the mathematics is in service of the context

   These questions are contextual questions, but the mathematics embedded in the context is used to inform and solve the contextual situation. These questions could mainly be found in Context driven and Content and context driven agenda (Graven and Venkat, 2007)

3. Dialectical questions

   These questions are asked to deepen both the mathematical understanding and contextual understanding; the mathematics informs the context, and vice versa. These questions could mainly be found in Context driven and Content and context driven agenda (Graven and Venkat, 2007)

4. Mathematical questions where the context is in service of the mathematics

   These are mathematical questions, but the questions use a contextual frame within which data is located and used to do the mathematics. The context is used as a vehicle within which mathematics is done. These questions are similar to the traditional word problems. These questions could mainly be found in Mainly content driven agenda (Graven and Venkat, 2007).

5. Mathematical questions

   These questions are purely mathematical with no reference to the context. The focus is on doing the mathematics; the context is not in service of the mathematics. These questions could mainly be found in Content driven agenda (Graven and Venkat, 2007)

The above classification of questions might be added to the spectrum of Mathematical Literacy teaching agendas developed by Graven and Venkat (2007).

The cognitive level of questions

The analysis of the cognitive level of questions included by Teacher A and Teacher B in the assessment tasks suggested the addition of low-level reflective questions to the existing Mathematical Literacy assessment taxonomy (DoE, 2008, p8). Therefore the following categories of questions are suggested:

1. Knowing questions
2. Applying routine procedures in familiar contexts
3. Applying multistep procedures in a variety of contexts
4. Reasoning and reflecting questions
5. Low-level reflective questions

Low-level reflective questions are questions that require contextual reflection based on personal opinion or experience; no mathematical reasoning or calculations are required to answer these questions.

6.2.1.2 Adaptation of the spectrum of Mathematical Literacy teaching agendas (Graven and Venkat, 2007)

It was noted in the section on the relationship between mathematical content and context that Teacher A worked partially within the Context driven agenda and the Mainly content driven agenda (Graven and Venkat, 2007), and that Teacher B's teaching practice could be placed in an adapted version of the Mainly content driven agenda (Graven and Venkat, 2007).

The analysis of Teacher A's teaching practice suggested the need for the possible inclusion of an additional agenda which focuses on the engagement and investigation of the context without engagement with the embedded mathematics. The agenda could be named the Context driven (without mathematical connections) agenda and could be placed to the left of the Context driven agenda (Graven and Venkat, 2007). This agenda could include Contextual questions, therefore purely contextual questions with the focus on the investigation of the context where no reference is made to the mathematics. This category of questions is described in the previous section in the classification of Mathematical Literacy questions. It could be critiqued that this agenda should not be included in the spectrum of Mathematical Literacy teaching agendas since it only includes discussion of context and no mathematics, and is therefore not suitable for Mathematical Literacy teaching practice. However, as a researcher I have to include this option since it follows from the empirical data collected from Teacher A's teaching practice.

Furthermore, it might be suggested that the Mainly content driven agenda (Graven and Venkat, 2007) is adapted to include the teaching practice followed partially by Teacher A and by Teacher B. The current agenda aims to 'learn maths and then to apply it to various contexts'. It was seen in the empirical data that the ACE teachers engaged with the context (in different ways and to different extents), and then followed the discussion of the context with the doing of mathematics using the contexts as a vehicle to do the mathematics, therefore to 'learn the context and then to use the context to do the maths'. Answers to the calculations would not necessarily be linked back to the context again. The context and the mathematical contents are largely dealt with separately and a dialectical relationship does not develop between the components. My suggestion is that the Mainly content driven agenda should be adapted to include both directions as explained above.

6.2.1.3 Ethical and moral values

The empirical data indicated the presence of ethical and moral value discussions in the Mathematical Literacy classroom. These discussions could lead to the development of the elements of ethics sensitivity, ethical reasoning skills and moral imagination (Tuana, 2007). It is feasible that class discussions lead to more than the development of ethics sensitivity and awareness with respect to a

moral issue, but are extended so that the teacher and learners identify, assess and reason facts and values in order to develop ethical reasoning skills and possibly moral imagination.

The spectrum of Mathematical Literacy teaching agendas (Graven and Venkat, 2007) may also be expanded to include reference to ethical and moral values discussions. The inclusion of value discussions will largely take place in the agendas where contextual discussions are emphasized, namely the newly described Context driven (without mathematical connections), the Context driven and the Content and context driven agendas. Value discussions, if the context calls for it, will feature more prominently in the Context driven (without mathematical connections) and the Context driven agendas than in the other Mathematical Literacy teaching agendas.

6.2.2 The ACE Mathematical Literacy course

6.2.2.1 Critical analysis of course literature

It was indicated that the course outcomes for Module 1, Introduction to Mathematical Literacy of the ACE course, included a critical analysis of national and international literature on Mathematical Literacy and the NCS curriculum documents and guidelines (DoE, 2003a; DoE, 2005; DoE, 2006; DoE, 2008). It appears that the two ACE teachers might have had the perception that regurgitating of the curriculum documents and course literature was expected from them in the situated context of assessment of the ACE Mathematical Literacy course. Their understanding and interpretation of the course outcomes might have been that they would obtain maximum marks for the course if they restated curriculum documents and other course literature. This analysis suggests that the teachers did not engage in critical analysis of course literature and largely did not develop their own voice with respect to the course literature as was expected.

This suggested that questions for formal assignments and examinations should focus on the application of theory learned and not merely on the reproduction of theory and facts. The cognitive level expected for an ACE course should not be restatement of course material, but should involve critical engagement with course material. The internalizing of knowledge and the construction of new ideas and meanings should be based on the course material and linked to experience.

6.2.2.2 Contextual nature of course assessment tasks

Following the advice in the Teacher Guide (DoE, 2006) and in Steen (2001), all the tasks that I set on the ACE course were located within an everyday context. The ACE Mathematical Literacy teachers were always given contextual data for the Mathematical Literacy lessons that they had to design as part of the course. Since the context was given, the teachers did not have a choice as whether to integrate the context in the planned lessons or not. The choice opened for the teacher was related to how to he/she should relate context and mathematical contents within the lesson structure. Of interest here is the fact that neither Teacher A nor Teacher B appeared to mention that all the tasks they had met in the ACE Mathematical Literacy programme were problem-solving tasks set in context. The

notion that all the tasks for the ACE Mathematical Literacy course were context-based could be critiqued since Mathematical Literacy tasks are not always context-based; tasks could also begin with content and then focus on applying the mathematics in different contexts. Evidence of this practice was apparent in the content-led Mathematical Literacy teaching agendas as described by Graven and Venkat (2007).

6.2.2.3 Development of the cognitive level of questions used in tasks

Evidence from the analysis of assessment tasks suggested that Teacher A and Teacher B did not include enough questions on a higher cognitive level, namely 'applying multistep procedures in a variety of contexts' (level 3) and 'reasoning and reflecting' questions (level 4). As mentioned previously, the tasks would largely not prepare learners for Paper 2 of the National Senior Certificate examination (DoE, 2008; Venkat and Phungula, 2008) since the overall cognitive level of the analysed questions was not high enough. This suggests that the ACE Mathematical Literacy course should emphasize 'learning' in relation to the design of tasks and the cognitive level of questions as advocated by the Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008).

6.2.2.4 A spectrum of Mathematical Literacy teaching practices

My intention, as course developer and presenter, was that each ACE Mathematical Literacy teacher would lead to the development of a teaching practice (Wenger, 1998) envisaged by the Department of Education (DoE, 2003a). Both teachers did not, in practice, integrate the components of context and mathematical content into a dialectical relationship (DoE, 2003a; Graven and Venkat, 2007) in the ways I expected, but developed unique Mathematical Literacy teaching practices which connected to the empirically based spectrum of teaching agendas (Graven and Venkat, 2007).

The empirical data from this study suggested that the ACE Mathematical Literacy course material should include the spectrum of agendas (Graven and Venkat, 2007) which includes different nuances for Mathematical Literacy teaching practice with regards to the relationship between context and content.

6.2.2.5 Development of meaning and Mathematical Literacy teaching practice

Although this study was based on only two teachers in the ACE Mathematical Literacy course and only one lesson of each was observed (which was a limitation of both the course and the research design), the empirical data demonstrated that the theoretical meaning which the two teachers gained on the ACE Mathematical Literacy course did not fully translate into their Mathematical Literacy teaching practice. The suggestion is that the course should include a practical component where teachers are expected to teach Mathematical Literacy as part of the ACE Mathematical Literacy course assessment. This component should include lesson planning, the set of classroom assessment tasks and lesson presentation. The purpose of the classroom practice would be diagnostic with respect to teaching practice of the teacher involved. The teacher, fellow-ACE Mathematical Literacy teachers

and the course facilitator would be required to reflect on his/her teaching practice in order to scaffold the development of a meaningful Mathematical Literacy teaching practice. In doing this the learning components of meaning and practice (Wenger, 1998) might successfully be integrated and might it be possible for the two components to 'mutually define' each other (Wenger, 1998, p5).

6.2.3 Mathematical Literacy teacher training

Whilst this study focused on only two ACE Mathematical Literacy teachers, the selected individuals (selected as explained in chapter 4) were 'typical' of the ACE Mathematical Literacy group of teachers and cannot be described as 'unusual cases' or 'outliers'. My findings from the two selected teachers suggest the need for urgent Mathematical Literacy teacher guidance and training so that teachers can make a coherent connection between contexts and the mathematical content required for solving real-life contexts. The teacher training should focus on the following two aspects:

6.2.3.1 Mathematical knowledge

The mathematics of the ACE teachers was not always coherent (Teacher A, Assignment 2: question 2, 11 September 2007) and some errors were made with respect to the mathematical content dealt with in the classroom (Teacher B: Lesson presentation, 13 September 2007). In addition to their own mathematical knowledge teachers should also be knowledgeable with respect to the GET mathematical curriculum in order to be informed of learners' expected prior mathematical knowledge. Teachers need mathematical training to support them to restore content gaps and set coherent questions with the appropriate level of difficulty.

6.2.3.2 The teaching of Mathematical Literacy

Mathematical Literacy teachers need to be informed of different Mathematical Literacy teaching practices to teach Mathematical Literacy in order to maximize student learning in their classrooms. If teachers are aware of the spectrum of teaching agendas (Graven and Venkat, 2007) and my expanded version, it may provide a tool that can be used to show the limitations of specific agendas and assist teachers to improve their planning and teaching in order to connect the contexts with the embedded mathematical content.

More attention needs to be given to the notion of 'situational sense-making and contextual orientation' (Venkat, 2010, p57), therefore understanding the real-life situation and the embedded mathematics. The aim of the training should be that the teaching practice reflects the proposed integrated connection between the components of contexts and mathematical contents. The training with respect to teaching practice needs to include training with respect to curriculum implementation, lesson planning, lesson presentation and the setting of assessment tasks.

Teacher training should not be restricted to the presentation of workshops or short courses, but ideally needs to be implemented over a longer term in order to assist teachers to successfully alter an existing practice or develop a new practice. The training should include a teacher practice component similar

to the practical component that is included in pre-graduate studies. This will give a teacher the time and space to reflect on his/her teaching practice and alter it if necessary.

6.3 The way forward

It was pointed out in the analysis of the curriculum documents that the documents send a dualistic message (Venkatakrishnan and Graven, 2006, p 20) to teachers on the manner in which Mathematical Literacy teaching should be conducted in the classroom. The need is pointed out that curriculum documents need to be aligned in one comprehensive document where a clear message is formulated on the nature and purpose of Mathematical Literacy teaching practice. The intention to compile a single policy document for all subjects was announced publicly by the Department of Education towards the end of 2009.

The analysis of the empirical research data points out that more research with respect to Mathematical Literacy teacher learning and teaching is necessary. Further possible areas of research based on my findings could include:

1. Mathematical Literacy teacher learning on an ACE Mathematical Literacy course and the indirect connections between the learning components of meaning and practice (Wenger, 1998).
2. Teachers' design of Mathematical Literacy questions in relation to my classification of five categories of questions and the ways in which cognitive demand plays out within these categories.
3. The limited use of technology, specifically the calculator, by the two ACE teachers in their Mathematical Literacy teaching, given the curriculum preference to use technology in the Mathematical Literacy classroom.

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8 Appendixes

8.1 Appendix A: Research consent form for learners and parents

4 September 2007

Dear Parent or Guardian

MSc Research Project

I am currently studying for a Master of Science degree in Mathematics Education at the University of the Witwatersrand in Johannesburg. As part of my thesis, I will determine whether (and how) the Mathematical Literacy teacher has developed his/her own understanding of Mathematical Literacy and whether (and how) the Mathematical Literacy ACE course has contributed to and improved his/her teaching of Mathematical Literacy. I will be observing a number of teachers in order to do this. I believe that through my research, I can make a meaningful contribution to more effective Mathematical Literacy teaching.

To this end I would like to observe your child's Mathematical Literacy class. The focus of my observation will be the teacher, ……., but I will be videotaping/audiotaping the whole lesson including the pupils as they participate in the lesson. Only my supervisor, Dr. Mellony Graven, and myself will have access to the videotape. The school will be anonymous and the anonymity of all participants will be assured. When reporting my findings, it is not my intention to make personal comments about the teacher or the pupils involved but rather to illuminate the processes and decisions involved in knowledge use. In this regard I undertake to ensure that no untoward references are made about the pupils or the teacher.

Lessons will continue as normal and as scheduled, with my presence in the back of the classroom.

I must stress that participation is voluntary. Your child is under no obligation to participate and there are no consequences should you or he/she choose not to. All research participants have the right to withdraw from the study at any point in time. I would be very grateful for this opportunity, however, and if you are agreeable to this process please read and complete the attached consent form and return it to the school.

All the data gathered for the study will be stored under lock and key in the School of Education at the University of the Witwatersrand, and destroyed at the completion of the analysis and reporting.

If you have any questions or concerns or would like to discuss the aims of my research in more detail, please do not hesitate to contact me on 082 414 8530. Should you wish to, you can also contact my supervisor, Dr. Mellony Graven on (011) 717 3411.

Yours sincerely

Janine Hechter

Consent form for participation in a research project.

(Please delete clearly where applicable)

I …….. **give consent / do not give consent** for my child to participate in the research project of Janine Hechter subject to the conditions laid out in the accompanying letter. These include the use of the transcripts for research purposes and in articles for publication in academic journals on condition that the school is anonymous and all participants are referred to by pseudonyms.

Name of learner: …….

Signature of learner: ……

Name of parent or guardian: ……

Signature of parent or guardian: ……..

Date: …….

Consent for videotaping/audiotaping

I, ……., agree to the videotaping/audiotaping of my child in the above-mentioned study.

Signature: ……

Date: ……

8.2 Appendix B: Research consent form for the school principal

4 September 2007

Dear Principal

MSc Research Project

I am currently studying for a Master of Science degree in Mathematics Education at the University of the Witwatersrand in Johannesburg. As part of my thesis, I will determine whether (and how) the Mathematical Literacy teacher has developed his/her own understandings of Mathematical Literacy and whether (and how) the Mathematical Literacy ACE course has contributed to and improved their teaching of Mathematical Literacy. I will be observing a number of teachers in order to do this. I believe that through my research, I can make a meaningful contribution to more effective Mathematical Literacy teaching.

To this end I would like to observe teachers in your school in a Mathematical Literacy classroom. The focus of my observation will be the teachers:

Teacher M

Teacher R

Teacher L

I will be videotaping/audiotaping the whole lesson including the pupils as they participate in the lesson. Only my supervisor, Dr. Mellony Graven, and myself will have access to the videotape. The school will be anonymous and the anonymity of all participants will be assured. When reporting my findings, it is not my intention to make personal comments about the teacher or the pupils involved but rather to illuminate the processes and decisions involved in knowledge use. In this regard I undertake to ensure that no untoward references are made about the pupils or the teacher.

Lessons will continue as normal and as scheduled, with my presence at the back of the classroom.

I must stress that participation is voluntary. The teacher and the pupils are under no obligation to participate and there are no consequences should you or he/she choose not to. All research participants have the right to withdraw from the study at any point in time. I would be very grateful for this opportunity, however, and if you are agreeable to this process please read and complete the attached consent form.

All the data gathered for the study will be stored under lock and key in the School of Education at the University of the Witwatersrand, and destroyed at the completion of the analysis and reporting.

If you have any questions or concerns or would like to discuss the aims of my research in more detail, please do not hesitate to contact me on 082 414 8530. Should you wish to, you can also contact my supervisor, Dr. Mellony Graven on (011) 717 3411.

Yours sincerely

Janine Hechter

Consent form for participation in a research project.

(Please delete clearly where applicable)

I ……. **give consent / do not give consent** for the teachers and pupils in my school to participate in the research project of Janine Hechter subject to the conditions laid out in the accompanying letter. These include the use of the transcripts for research purposes and in articles for publication in academic journals on condition that the school is anonymous and all participants are referred to by pseudonyms.

Names of the teachers: ……

Name of principal: ……...

Signature of principle: .……

Date: ...…….

Consent for videotaping/audiotaping

I, ……., agree to the videotaping/audiotaping of the teachers and pupils in my school in the above-mentioned study.

Signature: ……

Date: …..……..

8.3 Appendix C: Research consent form for the ACE Mathematical Literacy teacher

September 2007

Dear Teacher

MSc Research Project

I am currently studying for a Master of Science degree in Mathematics Education at the University of the Witwatersrand in Johannesburg. As part of my thesis, I will determine whether (and how), you, the Mathematical Literacy teacher, has developed your own understanding of Mathematical Literacy and whether (and how) the Mathematical Literacy ACE course has contributed to and improved your teaching of Mathematical Literacy. I will be observing a number of teachers in order to do this. I believe that through my research, I can make a meaningful contribution to more effective Mathematical Literacy teaching.

To this end I would like to observe …… in your Mathematical Literacy classroom. I will be videotaping/audiotaping your whole lesson including the pupils as they participate in the lesson. Only my supervisor, Dr. Mellony Graven, and myself will have access to the videotape. The school will be anonymous and the anonymity of all participants will be assured. When reporting my findings, it is not my intention to make personal comments about you or the pupils involved but rather to illuminate the processes and decisions involved in knowledge use. In this regard I undertake to ensure that no untoward references are made about the pupils or you, the teacher.

Lessons will continue as normal and as scheduled, with my presence in the back of the classroom.

I must stress that participation is voluntary. You, the teacher, and the pupils are under no obligation to participate and there are no consequences should you or he/she choose not to. All research participants have the right to withdraw from the study at any point in time. I would be very grateful for this opportunity, however, and if you are agreeable to this process please read and complete the attached consent form.

All the data gathered for the study will be stored under lock and key in the School of Education at the University of the Witwatersrand, and destroyed at the completion of the analysis and reporting.

If you have any questions or concerns or would like to discuss the aims of my research in more detail, please do not hesitate to contact me on 082 414 8530. Should you wish to, you can also contact my supervisor, Dr. Mellony Graven on (011) 717 3411.

Yours sincerely

Janine Hechter

Consent form for participation in a research project.

(Please delete clearly where applicable)

I …….. **give my consent / do not give my consent** to participate in the research project of Janine Hechter subject to the conditions laid out in the accompanying letter. These include the use of the transcripts for research purposes and in articles for publication in academic journals on condition that the school is anonymous and all participants are referred to by pseudonyms.

Name of the teacher: ….……..

Signature of teacher: ……

Date: …….

Consent for videotaping/audiotaping

I, ……., agree to the videotaping/audiotaping of myself, the teacher, and pupils in my school in the above-mentioned study.

Signature: ……

Date: …..……..

8.4 **Appendix D: ACE teacher profile form**

PERSONAL DETAILS

TITLE AND SURNAME: ……..

FIRST NAMES: …….

DATE OF BIRTH: ….……...

GENDER: ……

CELL NUMBER: ……

HOME TEL: ……

WORK TEL: ……..

HOME ADDRESS:

……

……POSTAL CODE ……

SCHOOL DETAILS

NAME OF SCHOOL: …….

SCHOOL PRINCIPAL:……...

SCHOOL TEL: ……FAX: ……..

PHYSICAL ADDRESS:…….

……

POSTAL ADDRESS:

……

……POSTAL CODE ……

TEACHING DETAILS

NUMBER OF YEARS TEACHING ……

MAIN SUBJECT(S) YOU HAVE TAUGHT DURING THE LAST 3 YEARS:

……..

GRADES TAUGHT AND NUMBER OF YEARS TEACHING THEM

GRADE	7	8	9	10	11	12
NO OF YRS TEACHING						
NO OF LEARNERS THIS YEAR						

NUMBER OF YEARS TEACHING MATHS LITERACY:

……

IF YOU ARE CURRENTLY TEACHING MATHEMATICAL LITERACY, WHICH GRADE(S) ARE YOU TEACHING? .....

BESIDES MATHEMATICAL LITERACY, WHICH OTHER SUBJECTS ARE YOU TEACHING?

……

TEACHER QUALIFICATIONS

	PART 1	PART 2
QUALIFICATION(S)		
YEAR(S) OBTAINED		
INSTITUTION(S)		
MAJOR SUBJECTS		
HIGHEST LEVEL STUDYING MATHS E.g. Matric or College Yr 2		

OTHER REGISTRATIONS

ARE YOU CURRENTLY REGISTERED WITH ANOTHER INSTITUTION (BESIDES WITS)?

……

IF YES, WHICH INSTITUTION? .....

WHAT PROGRAMME ARE YOU STUDYING FOR? ……...

THANK YOU

JANINE HECHTER

(011) 717 6070

8.5 **Appendix E: Portfolio 3**

Formulate a position on Mathematical Literacy

Refer to the following:

1. Description of Mathematical Literacy
2. Purpose of Mathematical Literacy
3. Pugalee's Mathematical Literacy model
4. Elements of Mathematical Literacy as described by Steen
5. The difference between Mathematical Literacy and "school maths"

(Limit: 0.5 p per heading)

8.6 Appendix F: Assignment 1

ACE (Mathematical Literacy)

HU0044

Module 1: Introduction to Mathematical Literacy

Assignment 1

Hand in: **Draft (optional) 20 March 2007**
Final 8 April 2007

Question 1

The inclusion of Mathematical Literacy (also known as numeracy /quantitative literacy/functional mathematics) as a school subject is an international trend in Education. Discuss how Mathematical Literacy as subject is viewed by the international community using the following headings:

1.1 Description of Mathematical Literacy as subject (5)
1.2 Purpose of Mathematical Literacy (5)
1.3 The elements of Mathematical Literacy as described by Steen (2001) (10)

[20]

Question 2

Pugalee (1999) has developed a model to describe Mathematical Literacy. He distinguishes between "process" and "enablers" as the main components of the model.

2.1 Name and describe the four processes through which learners access their mathematical knowledge to solve problems in real-life context. Illustrate the processes with examples in your own classroom. (12)
2.2 Name the 3 "enablers" that help to develop these processes. Explain the working of the "enablers" with the examples from your classroom. (8)

[20]

Question 3

The following is a quote from the NCS for Mathematical Literacy (DoE, 2003):

"The FET subject, Mathematical Literacy, should enable the learner to become a self-managing person, a contributing worker and a participating citizen in a developing democracy. Mathematical Literacy will ensure a broadening of the education of the learner which is suited to the modern world. Mathematical Literacy contributes to the attainment of the Critical and Developmental outcomes"

Explain how the critical and the developmental outcomes are linked to and interpreted for Mathematical Literacy. Illustrate with examples from your own classroom. [30]

Question 4

The following are abstracts from the NCS for Mathematics and Mathematical Literacy (DoE, 2003):

MATHEMATICAL LITERACY (FET):
LEARNING OUTCOME 2: FUNCTIONAL RELATIONSHIPS
The learner is able to recognise, interpret, describe and represent various functional relationships to solve problems in real and simulated contexts.

MATHEMATICS (FET):
LEARNING OUTCOME 2: FUNCTIONS AND ALGEBRA
The learner is able to investigate, analyse, describe and represent a wide range of functions and solve related problems.

What is the difference between teaching mathematics and Mathematical Literacy? Illustrate your explanation with examples from the maths and maths literacy classroom referring to LO2. [10]

Question 5

Discuss overlaps and contrasts in Mathematical Literacy (Functional Mathematics) in South Africa and England. Refer to the following points:

5.1	Course emphasis	(5)
5.2	Course organization	(5)
5.3	Curriculum focus	(5)
5.4	Assessment	(5)

[20]

Total: 100 marks

8.7 Appendix G: Interview with Teacher B (13 May 2008)

1. How has your understanding of the nature and purpose of Mathematical Literacy as subject changed over the course of the last 18 months? Explain. (Meaning)
2. How do you think your Mathematical Literacy teaching has changed over the course of the last 18 months? In Questionnaire 2 (September 2007) you state that your teaching has changed, because you state that with the design of the Smokers' data lesson 'the content allowed me to unfold the context. I used the maths content to explain what the context was all about'. How might we understand this? How do you feel you were able to do the above in your teaching of the smokers' task? What might you have done previously? (Practice)
3. In Questionnaire 2 (September 2007) you state: 'I am now able to differentiate between maths and Mathematical Literacy. I am able to write meaningful lesson plans and know what I am teaching unlike before when I was teaching maths instead of Mathematical Literacy.' What do you mean with the above statement? (Probe: that you taught maths in the Mathematical Literacy classroom, not Mathematical Literacy?) (Practice)
4. What sources helped you with the style of questioning you designed for the worksheet for the smoking data? What's guiding your practice? (Probe: text book? Work sheets? Workshops?) (Practice)
5. Which textbook do you use? (Probe for influence of text book, workshops or courses on the style used for questions in worksheet). Why did you choose this particular text book? What is your experience / view of how the text book meets or doesn't meet the curriculum aims? (Practice)
6. What is your view of the use of technology in your Mathematical Literacy classroom? Do you use calculators in your class? If so, basic or scientific calculators? Any other kinds of technology? What is your view of the use of calculators and other technology? (Technology)
7. What made you choose the heading 'the war against smoking' in portfolio 1 (20 February) (Value perspective)
8. Have you taught other contexts similar to the smoking task where you have taken a personal stance on the issue? If so, indicate the topics. Did the topics push you to take a personal stance and share your opinion with the class? How did you share your opinion with the learners? Do you think this is important to do? (Value perspective)

8.8 Appendix H: Interview with Teacher A (24 May 2008)

1. How has your understanding of the nature and purpose of Mathematical Literacy as subject changed over the course of the last 18 months? In Portfolio 3 (13 March 2007) you state: 'Mathematical Literacy is more a habit of mind and approach to problems that employs and enhances both statistics and mathematics. It is inseparable from context, contents develops from contexts and grows more horizontally than vertically.' Explain what you meant with the above statement. (Meaning)
2. How do you think your Mathematical Literacy teaching has changed over the course of the last 18 months? When asked in Questionnaire 2 after your video lesson in October 2007 how your teaching changed over the year, if at all, you stated: 'It's better than before'. How might we understand this? How do you feel you were able to do the above in your teaching of the smokers' task? What might you have done previously? (Practice)
3. When asked in Questionnaire 2 after your video lesson in October 2007 how you thought about the relationship between content and context, you stated: 'They interact. With context one understands content better. Context helps learners to understand better and with that they are eager and it's easy for them to catch up with content.' How might we understand this? How do you feel you were able to do the above in your teaching of the smokers' task? What might you have done previously? (Practice)
4. In Assignment 1 (10 April 2007) you state: 'When teaching Mathematical Literacy is when you involve maths acting in the world where appropriate skills are used in different contexts'. What do you mean with the above statement? (Meaning)
5. What sources helped you with the style of questioning you designed for the worksheet for the smoking data? What's guiding your practice? (Probe: text book? Work sheets? Workshops?) (Practice)
6. Which textbook do you use? (Probe for influence of text book, workshops or courses on the style used for questions in worksheet) Why did you choose this particular text book? What is your experience / view of how the text book meets or doesn't meet the curriculum aims? (Practice)
7. What is your view of the use of technology in your Mathematical Literacy classroom? Do you use calculators in your class? If so, basic or scientific calculators? Any other kinds of technology? What is your view of the use of calculators and other technology? (Technology)
8. In portfolio 1 (20 February) you start your lesson with the following statement: 'Smoking has been a norm and has been/is being practiced in our society. It's everywhere (used in all forms of media, e.g. magazines, TV) hence creating the attitude amongst people of 'it's okay to smoke' and 'he is smoking, why can't I?' and 'Smoking hazards are not

widely promoted as smoking in general is portrayed in advertisements or in our daily lives.' What do you mean with the above statement? (Value perspective)

9. Have you taught other contexts similar to the smoking task where you have taken a personal stance on the issue? If so, indicate the topics. Did the topics push you to take a personal stance and share your opinion with the class? How did you share your opinion with the learners? Do you think this is important to do? (Value perspective)