An exploration of the strategies used by grade 12 mathematical literacy learners when answering mathematical literacy examination questions based on a variety of real-life contexts.

By

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ABSTRACT

With the introduction in 2006 of the school subject Mathematical Literacy (ML) in the further Education and Training band, there have been expectations that such a subject will develop responsible citizens, contributing workers and self-managing people. The extent to which the subject can meet these aims is dependent on the ways in which the subject is assessed which influences the focus of ML in the classrooms. With this in mind, this study set out to explore the ways in which a class of Grade 12 learners engaged with a preparatory examination designed and administered by the KZN Department of Education.

This is a qualitative study carried out with seventy-three grade 12 mathematical literacy learners from an urban school in North Durban. The purpose of this research is to explore the learners' engagement with the examination tasks, thereby identifying possible factors which influence learners' success in these items. Data were gathered from a document analysis of the 2009 KZN Trial Examination question paper and marking memorandum; 73 learners' written responses to the examination tasks, and interviews with ten of these learners. The purpose of the document analysis was to identify contexts in which learners performed well or poorly, as well as to assess the design of the instrument. Semi-structured interviews were conducted individually with ten learners and video recorded. The purpose of the interviews was to explore some of the factors which influenced their written responses. The findings revealed that the task design was problematic for learners in terms of the order of the questions and the placement of the crucial information necessary to answer the questions. Some tasks also contained errors. The complexity of the scenario in terms of the amount of information, the language used, and the presence of distracters further influenced the way in which learners responded to the task. Learners' personal experience of the context also affected the way they interpreted and responded to the task. Factors that constrained learners' success in the examination task included poor conceptual understanding, misconceptions and language-related misinterpretation. It was also found that learners did not consider it a priority to make sense of the context: they focused on identifying formulae or information that could be used to present answers with little concern about the reasonableness of their responses. Some strategies used by learners in responding to the task included number grabbing, guessing without checking, scanning for crucial information and assumption-making.

The study recommends that provincial examination papers be subject to the same stringent moderation requirements of the national examinations. It also recommends that should diagrams be used, they must be relevant to the context and should not conflict with the subject matter. The use of contexts should cater for alternate answers and multiple approaches and the marking memorandum should be flexible to accommodate these multiple approaches. Care must be taken in the presentation and placement of crucial information, so that learners do not miss the information they need to answer the questions. When familiar contexts are being used, task designers should also consider whether learners' everyday experiences may conflict with these scenarios.

PREFACE

The work described in this thesis was carried out in the School of Science, Mathematics and Technology Education, University of KwaZulu-Natal, from **January 2009 to November 2011** under the supervision of **Dr Sarah Bansilal** (Supervisor).

This study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others, it is duly acknowledged in text.

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The culmination of this dissertation would not have been possible without the assistance and motivation from various significant people, including my supervisor, colleagues, family, friends and students.

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DEDICATION

To my wife, Vashnee Debba and son, Shaunak Debba

Whom I ‘deprived’ of quality time during the completion of this study;

My mum, who always encouraged me to persevere.

My brother, Dr Pravesh Debba, whose words I will always remember:

“You cannot finish if you do not start”.

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Mathematical Literacy was introduced into the South African school curriculum in 2006 at the Grade 10 level. The motivation for this was partly to alleviate the high levels of innumeracy and mathematical illiteracy that exists in the country (DOE, 2003, p.9). At the end of 2008, about 260 000 Grade 12 learners wrote the first Department of Education (DOE) National Senior Certificate (NCS) examination (North, 2010). Prior to this, the subject Mathematics was optional with a choice of taking the subject either on the Higher Grade or the Standard Grade. Standard Grade Mathematics was widely viewed as a watered down version of the more demanding Higher Grade Mathematics. Under the new NCS system, Higher and Standard Grade Mathematics have been merged into one subject called Mathematics, with its alternative Mathematical Literacy[1] making the study of one or the other compulsory. In this chapter, I examine the position and status of Mathematical Literacy as a learning area in the South African curriculum and present the rationale and motivation for this study.

1.2 FOCUS AND PURPOSE OF STUDY

The period from 1994 to the present has seen South African Education undergoing dramatic transformation. The phasing in of Outcomes-Based Education (OBE) was an attempt to make education more meaningful and relevant to society (DoE, 2006). Mathematics transcends almost every sphere of life. It is imperative that South African citizens are mathematically literate. The introduction of Mathematical Literacy, in 2006, in the Further Education and Training (FET) band, is an attempt to make South African citizens mathematically literate, as described below:

> *Being literate in Mathematics is an essential requirement for the development of the responsible citizen, the contributing worker and the self-managing person. Being*

[1] Throughout this thesis, I use the capitalised "Mathematical Literacy" to refer to the school subject in South Africa and the lower case "mathematical literacy" to refer to the general notion of a life-related competence that has a significant literature base associated with it in the field of mathematics education.

> *mathematically literate implies an awareness of the manner in which Mathematics is used to format society and enables astuteness in the user of the products of Mathematics such as hire-purchase agreements and mathematical arguments in the media – hence the inclusion of Mathematics Literacy as a Fundamental requirement in the Further Education and Training curriculum.* (DoE, 2006, p.43)

The above excerpt emphasises that Mathematical Literacy is a move away from purely 'mathematical' issues to those that demand a need to make sense of the world around us using mathematical tools and thinking. This move calls for making sense of real life contexts and using basic mathematics to find solutions to real life problems. Even the new Mathematics curriculum places emphasis on non-routine problems taken from real life contexts. In practice, however, the emphasis in mathematics classrooms has been on solving routine mathematical problems in a context-free environment. Even on the odd occasion when a "real life" problem or example is discussed in the classroom, it is typically a rather artificial problem created for the purpose of fitting it into the topic in question. The problem is usually complete by itself, and is presented in a very clean and tidy state. Such practices make it difficult to convince the learner that real life applications of mathematics do indeed exist (Cheng, 2001).

In my experience, the typical traditional mathematics lessons usually took the form of teacher exposition and learner application followed by remedial work. Learners were presented with similar examples for application as the ones the teacher explained during his/her exposition. Learners would then immediately engage in the examples on their own. Nowadays, learners are expected to engage with a context with minimal input from the teacher, who is seen as a mediator in the learning process. My experiences in a number of Mathematics and Mathematical Literacy classes have shown that, under these conditions, learners tend to 'wait' for the answers from the teacher because they do not know where they should start. They are often adept at camouflaging this 'waiting period' by using delay tactics such as taking a long time to retrieve their mathematics workbook and writing down the date and heading, waiting for a ruler or a pencil from a peer, and reading the context, often pretending to read only when the teacher approaches him/her. When forced to write down solutions, learners scribble something in pencil. When the use of a pencil is questioned, learners reply that they are not sure if their answer is correct. With ML learners, who are often weaker than the learners who have chosen mathematics, their struggles are more evident. These responses are indicative of the low self-esteem and poor confidence learners have of themselves when engaging in context-based mathematics. Teachers' obsession with learners getting the "right answer" stems from a world view which sees mathematics as "absolute truth". Such a view hampers the ability of learners to engage in discovering mathematics.

In my experience of teaching mathematical literacy, I found that many learners cannot make sense of the context in which the questions are embedded because of poor general knowledge on a variety of issues. This limits them. When learners pursue deeper aspects of the context, they may feel "unsettled because they do not have the relevant general knowledge or their general knowledge may be irrelevant or too far from the content, that they revert to a more content focussed agenda" (Kasanda, et al., 2005). Many learners from my secondary school come from a low socio-economic background. Their relevant general knowledge is often limited and hence they are not able to engage fully with the given context. It is also the case that learners do not draw upon their logic and reasoning skills when faced with contextualised tasks. An example from a Grade 11 class will elucidate my point. I was teaching a topic in Functional Relationships which involved the following example: Given that each lion consumes 7kg of meat, learners were asked how many lions could be fed with 40kg of meat. The common answer, when detaching the context, was 5.7 lions. However, when taking the context into account, learners realise that one cannot get a fraction of a lion and hence there is a tendency to round *up* the answer to 6 lions. However, the use of logic and reasoning would imply that 40kg of meat would be too little to feed 6 lions and hence one needed to round *down* to 5 lions (with 5kg of meat remaining). Of course 6 lions is also an acceptable answer if the learner is able to explain (and the examiner is able to accept that there can be other logical real life solutions!) that it is not a train smash to feed each of the 6 lions a little less that 7kg of meat (6.67kg to be precise). Investigating the strategies used by learners, which is the focus of my study, may help us identify other similar problems.

Difficulties with contextually based problems are further exacerbated amongst learners for whom English is a second language. When faced with unfamiliar contexts the language barrier may impede their understanding and consequent performance. Poor performance generates unmotivated learners in the mathematics classroom. I often hear learners say "mathematics is not for me", or "I do not like mathematics" or "if I fail only mathematics, I will still pass" (i.e. progress to the next grade), and so on. Such attitudes result in many learners wasting much time doodling, writing and passing notes to friends or completing work for other learning areas. As I walk amongst learners, they suddenly pretend to be engaged in the activity. I notice their workbook and on return a few minutes later, find that they have made little or no progress at all. I often hear learners asking another learner "how many minutes are left?" (for the end of the period). When portfolio assessment activities are required, many of these learners do not have the conceptual knowledge to successfully attempt or complete them. They either do not submit assessments for marking (as they know that if they fail mathematics, they would still progress into the next grade) or simply reproduce other learners work as their own after been pressurized by the subject teacher, school management and/or reports/telephone calls to their parents. The problem is essentially part of a bigger problem. Firstly, learners coming from the primary school to the secondary school have inadequate foundational work in mathematics to develop further mathematics. Secondly, continuous assessments as well as the pass requirements have made it possible for learners to pass without having developed sufficiently to be able to cope in the following grade; and thirdly, the lack of motivation due to the inability to see the relevance of mathematics beyond the classroom and for their personal gain. Fourthly, many learners who study ML have been compelled to take it on because of school norms which did not allow them to continue their studies in mathematics from Grade 10 onwards because of low marks. These issues, particularly the latter two, may result in learners showing disinterest in the subject because mathematics offers no meaning for them. Hence, such learners have not developed the appreciation for the meaning of mathematics because they do not recognise links between school mathematics and out-of-school activities. These personal experiences and reflections have led me to undertake the study with the aim of exploring the strategies learners use when responding to ML assessment tasks set in various contexts. By so doing, I hope to identify factors which affect their success in these tasks.

With the introduction of Outcomes-Based Education and the new curriculum changes, much research has been done on teaching styles. Over the years the expectation of teaching styles have changed: they are now more discussion-based, less paced and less pressured, with more time for understanding (Venkat & Graven, 2007). Little research has been done on how learners learn in the changed circumstances and the strategies they adopt. The ways in which learners interact with the context to find solutions also need to be studied extensively. Hence, my aim in this research is to explore learners' engagement with the examination tasks, thereby identifying their successes and failures in these items.

It is hoped that researching learners' thinking strategies would assist teachers to understand how learners' think through mathematical contexts and add to knowledge about the considerations made by ML learners when responding to assessment tasks. It would also motivate teachers to become aware of their own learning and teaching styles in mathematics, and would provide advice to task designers on aspects that must be considered in choosing contexts and designing valid assessment tasks.

1.3 DETAILS OF STUDY

In Chapter 1, I described the position of Mathematical Literacy in South Africa and the focus and purpose of the study.

Chapter 2 reviews recent studies on the teaching and learning of Mathematical Literacy in South Africa and the role played by contexts in the teaching and learning of Mathematical Literacy. Aspects on the design of assessment tasks are outlined and the role played by mathematical modelling in Mathematical Literacy is considered. The chapter concludes with the theoretical framework that underpins this study.

Chapter 3 outlines the research methodology and the design of the study. It describes the contexts in which the study was undertaken and the characteristics and selection of the sample. This chapter also describes the qualitative paradigm on which this study was based, the design of the study corresponding to the four research questions and the data collection methods that were used. The chapter also discusses the criteria considered to ensure reliability, validity and trustworthiness of this research.

Chapter 4 describes how the learner's responses were statistically analysed by re-marking learner's scripts and arranging their marks per questions in ascending and descending order in terms of getting full marks, part marks or no marks for each question. A document analysis of the examination task was performed and the various tasks were grouped in terms of types of contexts.

Chapter 5 provides an analysis of the interviews and learner's responses to the examination tasks. The design of the examination task was analysed in terms of the role of diagrams and errors and inconsistencies in the paper and marking memorandum. Learner's responses were analysed in terms of factors that constrained learners' success in the task, the strategies used by learners when answering the examination questions, and learners' perceptions and experiences of the contexts.

In Chapter 6, I provide answers to the four research questions. I identify limitations and discuss some implications of the study. I conclude this chapter with suggestions for future research.

CHAPTER 2

LITERATURE REVIEW

In this chapter I first present a review of relevant literature and thereafter a description of the theoretical framework which guides this study.

2.1 REVIEW OF RELATED LITERATURE

In this review I will firstly describe the background to Mathematical Literacy in South Africa; secondly, the role contexts plays in the teaching of Mathematical Literacy; thirdly, the design of the assessment tasks in Mathematical Literacy, and finally, the role modelling plays in Mathematical Literacy.

2.1.1 Background to Mathematical Literacy in South Africa

Post-1994 saw many dramatic transformations in South African Education. This educational change has been stimulated by the major political changes which occurred in the country during the 1990s and which brought about the abolition of apartheid and the introduction of a democratic South Africa.

Curriculum 2005 (C2005) was the new curriculum designed to transform South African education from apartheid to a post-apartheid society.

> *The curriculum is at the heart of the education and training system. In the past the curriculum has perpetuated race, class, gender and ethnic divisions and has emphasised separateness, rather than common citizenship and nationhood. It is therefore imperative that the curriculum be restructured to reflect the values and principles of our new democratic society* (DoE curriculum 2005, A user's guide, 1997)

The approach adopted to drive the new curriculum was Outcomes-Based Education (OBE). The aim of OBE was to integrate education and training into a system of lifelong learning. South Africa comes from a past in which poor quality or a lack of education resulted in very low levels of literacy and numeracy in our adult population. International studies like the

Trends in International Mathematics and Science Study (TIMSS) show that, when compared to learners from other countries, South African learners performed very poorly (Howie, 2004).

The inclusion of Mathematical Literacy as a fundamental subject in 2006 in the FET curriculum was an attempt to "ensure that our citizens of the future are highly numerate consumers of mathematics" (DoE, 2003, p.9). Mathematical Literacy is defined in the curriculum statement in the following terms:

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

The phrase 'awareness and understanding' in the definition emphasises the need to 'see' the world quantitatively, participating in and interpreting its activities. What makes Mathematical Literacy different from Mathematics is that Mathematical literacy is embedded in context. The phrase 'driven by life-related applications of mathematics' emphasises the need to "engage in contexts rather than applying mathematics already learnt to the context" (DoE, 2003, p.42). In order to successfully engage in the context, it becomes necessary to first understand the context. A misunderstanding of the context can negatively affect learners' performance in assessment tasks. In an assessment task, particularly, it would be unfair to candidates if the contexts are unfamiliar and the necessary information is not readily accessible. The ML taxonomy recognises familiarity of contexts as a factor affecting the difficulty level of tasks, because level 2 tasks are specified as familiar context suggesting that tasks that are set within unfamiliar contexts require a higher level of engagement. However this does not mean that learners should only work with mathematising familiar contexts. Within a classroom setting, opportunities must be provided for learners to work with unfamiliar contexts, however when unfamiliar contexts are used in an examination setting, it is crucial that the necessary information must be available and accessible to the learner.

Although relatively new in South Africa, Mathematical Literacy as a subject has been around for quite some time in other countries and referred to by different names such as Quantitative

Literacy, Numeracy and Critical Numeracy (Stoessiger, 2002; Steen, 1999; Madison, 2006). The common strand among them is that they all deal with mathematics in context.

2.1.2 Recent Literature about Teaching and Learning Mathematical Literacy in South Africa

The introduction of Mathematical Literacy in the South African Further Education and Training (FET) curriculum in 2006 generated mixed feelings of uncertainty and hope. There was uncertainty as to whether making mathematics compulsory (learners must take either Mathematics or Mathematical Literacy) was in fact a good idea, considering that previously learners had the choice of not studying Mathematics at all; whether learners who are forced to take Mathematical Literacy would be motivated enough to make a success of the subject; whether learners who were 'forced' to take Mathematical Literacy would have the ability to cope with the demands of the new subject; whether there would be appropriate and sufficient resource materials to successfully implement the subject in the FET phase; whether teachers would be able to make the shift from teaching Mathematics to teaching Mathematical Literacy; whether the training of teachers would be appropriate and successful to take on the challenges of teaching a new subject; what the matric assessment would look like, and the status of Mathematical Literacy in terms of access to further studies. In the same breath, Mathematical Literacy was welcomed with hope that it would enable learners to become active participants in society; it would make mathematics more relevant to the lives of learners by focusing on real-life contexts; it would encourage everyday problem solving; develop the confidence in learners to think numerically and spatially, and would make learners more marketable in the job market.

Since then a number of studies have been undertaken that have implications for the teaching and learning of Mathematical Literacy in South Africa. The following sections detail some of the recent literature on the issues related to the teaching and learning of contextualisation of mathematics tasks as well as studies on the teaching and learning of Mathematical Literacy in South Africa.

In a qualitative study of one urban South African Grade 9 mathematics classroom, Bansilal and Wallace (2008) examined how a classroom teacher, Vani, interpreted and implemented the national assessment tool known as the Common Tasks for Assessment (CTA), which was designed around a number of tasks based on a single context, the theme of Robben Island. The purpose of this summative assessment was to ensure the validity, reliability, and fairness of assessment procedures and contribute to credibility and public confidence in the education system (DoE, 2002b). Their analysis revealed six issues of concern in the conduct of the CTA: knowledge gaps, task language, information overload, lexical density, messy numbers and real life contexts.

It was found that many learners in Vani's class struggled with the mathematical concepts used in the CTA due to a deficit in basic skills and foundational knowledge referred to as 'gaps in knowledge'. These 'knowledge gaps' were characterised by learners inability to use a ruler appropriately for accurate measurement, omitting numbers necessary in calculations, and showing lack of understanding of the meaning of terms such as 'mode'. The learners' poor language skills skewed understanding of the context as well as the instructions, thus compromising their responses to the task. Bansilal and Wallace also found that the 'context information' that was used to paint a picture of the context created an 'information overload', and thus interfered with learners' ability to extract the 'crucial information' necessary to solve the task. Evidence for this was when learners attempted to measure the dimensions of the bed and the cell from the diagram (which was not drawn to scale); copying the figures used by Vani as examples from the board, and concocting their own numbers probably after seeing Vani making up numbers on the board for her examples.

The researchers also found certain questions in the CTA to have high lexical density or a high number of lexical items (or content words) per clause. One such question had a lexical density of 13 content words per clause compared to two content words per clause in informal spoken language and four to six in written English. This made the instructions complex and difficult to comprehend. The numbers used in the tasks were not rounded off. These 'messy numbers' created confusion and added to the learning problems. The real life contexts of prison dormitories and weather patterns, were not within the learners' own experiences and thus learners resorted to considering their own experiences in answering the questions as opposed to engaging with the actual mathematical processes.

Bansilal and Wallace (2008) concluded that learners did not have an adequate background to undertake such assessment. By Vani explaining certain concepts and scaffolding information to assist learners, the reliability and validity of the CTA was compromised and they recommended that policy-makers needed to take these factors into account.

Bansilal and Khan (2009) in another study explored how one learner, Cleo, experienced the CTA which was grounded in a 'real-life' context, the theme being the Kruger National Park. The researchers revealed four aspects in their analysis of Cleo's case. Some aspects were similar to those found in the study by Bansilal and Wallace. Firstly, due to 'information overload', Cleo was unable to extract the 'crucial information' such as 'minimum cost'; 'child over 12 years was regarded as an adult' and used the cost for an additional child instead of the cost for an adult. In an interview, Cleo expressed her dissatisfaction with the amount of language and literary passages that she had to wade through. Secondly, Cleo was disadvantaged by her teacher's marking when she omitted the units in her calculations even though her calculations were correct. Thirdly, Cleo's experience of the context of a holiday (staying at home) differed from that utilised in the tasks (holiday to Kruger National Park). She was therefore not familiar with the specialised language, such as 'base occupancy' and 'additional person supplements', used in the context. Fourthly, when Cleo did not understand the problem to be solved, she resorted to 'number grabbing' to enable her to perform calculations and obtain an answer. The study has shown that learners experience 'real life' differently from adults (like the task designer), and that these real life contexts may not be accessible to learners.

Contrary to the many difficulties expressed by learners in the preceding study, in their engagement with contextually based questions, Venkat & Graven (2008) examined learners' perceptions of Mathematical Literacy in Grade 10 in an inner-city Johannesburg school and were able to show that highly negative experiences of learning Mathematics in Grade 9 had been transformed into highly positive perceptions of learning Mathematical Literacy across 2006 – the first year of the subject's implementation in schools. Through information gathered from questionnaires and interviews with selected learners, Venkat and Graven were able to attribute this positive perception of Mathematical Literacy to the opening up of learning spaces within the classroom in terms of what learners described as shifts in the nature of classroom tasks and in the nature of interaction in Mathematical Literacy. In terms of the nature of classroom tasks, learners viewed contextual tasks as more accessible, practical, 'visualise-able' and providing openings for communication, participation, and sense making inside and outside school. The nature of 'scenario' mentioned by learners is different from the traditional ‘word problem’ encountered in mathematics and may explain learners’ positive response to mathematical literacy tasks. The concrete nature of tasks helped to ‘see’ what was being discussed and aided in sense making. The ‘ease’ of Mathematical Literacy was interpreted as ‘simple’ when compared to Mathematics but not as simple as it seemed, as one learner justified when she gave a friend who was good in Mathematics a problem to do in Mathematical Literacy, but which her friend was unable to solve.

In terms of classroom interaction, Venkat and Graven (2008) reported that learners expressed having more time to understand in Mathematical Literacy because of the slower pace, learner centeredness, working in pairs and groups and the availability of alternate problem solving methods. The extended use of communication and discussions in class of scenarios, scaffolded learners’ access to problem situations in comparison to mathematics. Both these shifts provided openings for learners to communicate and participate in classroom activity, in addition to gaining understandings and make sense of the mathematics being used. Venkat and Graven noted in their paper “an absence of comments from learners about difficulties in accessing questions or contexts in spite of the often extensive use of English text, which we expected to be a problem for our sample of learners for whom English was a second or third language” (p.39). The authors have used this absence of complaints about language difficulties, to infer that the extensive use of language therefore did not present problems.

Bansilal, Mkhwanazi and Mahlabela (2010) conducted a qualitative study to explore how practising Mathematical Literacy teachers who were studying for the Advanced Certification of Education (ACE) in Mathematical Literacy at the University of KwaZulu-Natal, engaged with financial mathematics concepts appearing in mathematical literacy tasks, to identify factors that supported or impeded their success at solving such tasks. The findings showed that these teachers often did not use their reasoning or common sense to judge the reasonableness of an answer. For example, one student wrote R7 062 000 as the monthly instalment on a bond for R550 000, an amount which was significantly higher than the bond amount. The lack of procedural fluency was demonstrated when students simplified R15 000(1+ 0,35t) to R15 000(1,35 t). One student, when questioned about this error, could not see why 1 + 0,35t did not equal 1,35t. The researchers concluded by saying that success at solving contextualised mathematics problems is dependent on successful participation in both the conceptual and contextual domains.

The design of assessment tasks can also affect learners' performance in an examination setting. Assessment tasks should have an appropriate balance amongst the levels of questions as well as the content being tested. North (2010), in his analysis of the 2008 Grade 12 Mathematical Literacy Examination paper, found that it did not adhere to the stipulations of DoE assessment documents in terms of content coverage and cognitive difficulty. In terms of content coverage, LO1 (Numbers and Operations) were over-assessed, while LO2 (Functional Relationships) and LO3 (Shape, Space and Measure) were under-assessed. Assessment of several topics such as inflation, taxation, quartiles, percentiles, and graphs with negative axes, were completely omitted. The imbalanced distribution of marks according to the taxonomy levels, where a low percentage of marks were allocated to Reasoning and Reflecting and a high percentage of marks allocated to Routine Procedures, made the examination assessment cognitively less demanding, and hence contributed to a false impression of the high pass rate in the subject in 2008.

2.1.3 The Role of Contexts in Teaching Mathematical Literacy

An awareness of employer dissatisfaction with school learners as well as general reports of adult inability to transfer mathematics learned in school, prompted a vocational shift towards 'everyday' use of mathematics (Boaler, 1993). Studying 'everyday' mathematics prepares learners to solve real world problems, providing a bridge between the abstract role of mathematics and their role as members of society. Hence, 'mathematics in context' focuses on budgeting, bills, banking, income tax, reading electricity bills, and so on.

Previously, mathematics was associated with a cold, detached, remote body of knowledge (Boaler, 1993). The use of contexts is more subjective and personal, improving the ability of learners' to interpret events around them. Analysing and interpreting real world, local community and even individualised examples, allows learners to understand reality by becoming involved in mathematics and breaking down the perception of mathematics as a remote body of knowledge. This 'remote body of knowledge' has been identified by learners in Venkat and Graven's (2008) study on learners' experiences of Mathematical Literacy in Grade 10. They found that in comparison to mathematics learned in Grade 9, learners found Mathematical Literacy to be easy to understand because

> *...it was comprised by 'scenarios' or 'story sums'; these were contrasted with the 'x's and 'y's which clearly haunted many of their mathematical memories. The scenarios were described as being easy to understand, access and to 'see', again contrasting with the lack of access to sense making and understanding that they appeared to have experienced in Mathematics* (p.35).

Historically, mathematics was seen as a subject of 'absolute truths' with the existence of one correct answer to each problem. The use of contexts aims to counter this view by encouraging negotiation and interpretation. Venkat and Graven (2008) write that the use of context creates confidence in students by developing their capacity to understand development and use of mathematics.

> *Related to the notion of applicability to real-life, many learners' commented on ML as being more 'useful' than Mathematics, with 'usefulness' linked to everyday situations, future needs and in particular, careers linked to business and accounting. Connected to this idea of relevance to real life, several learners talked about potentially using the concepts and skills learnt, and some talked about ML learning in terms of active current use outside lessons in ways they had not been able to do previously* (Venkat & Graven, 2008, p.34).

Mathematical Literacy in the NCS for the FET band attempts to integrate content with contexts. No longer is Mathematical Literacy seen or taught in isolation. Bernstein (1982) refers to this type of integration as weakened classification – reduced insulation between contents, for the boundaries between contents are weak or blurred. Mathematical Literacy also allows for a greater degree of freedom over the selection, organisation, pacing and timing of the knowledge transmitted and received in the pedagogical relationship. Bernstein refers to this as weakened framing.

> *Traditionally, school mathematics is seen to be strongly classified and framed as it is often taught as a discipline quite distinct from others and taught in a way where there is an emphasis on specialised skills; the teacher taking a dominant position in the class* (Zevenbergen & Lerman, 2001, p.572).

The position described above is different from the envisaged classroom as presented in South African policy recommendation where the boundaries between learning areas have weakened, with the teacher assuming the role of a facilitator (DoE, 2006).

However, many research studies have demonstrated that teaching and assessing mathematics using contexts is not as simple as it seems. "What is real, everyday or relevant, or has meaning, depends on things far more complicated than tutors can know" (Tomlin¸2002¸ p.8).

There is a belief that learning mathematics through context improves transfer to the real world. Interviews with learners in Venkat & Graven's (2008) study provides some evidence of transfer between in-school learning and out-of-school use. For example, working on the structure of real cellphone contracts in class allowed some learners to do similar calculations in real-life, and similarly, discounts offered in sales – an issue covered in class – was also actively used during shopping. Many justifications have been made to show why it is beneficial for students to have mathematics burdened with contexts. They include ease of access, user-friendliness, attractive and colourful page layout and pupil motivations (Feu, 2001). Tsai (1999), in her study with Taiwanese high school learners, found that although contexts improved students' understanding of the nature of science, these improved ideas are not declared openly and hence there is limited transfer to new situations.

Real world contexts are used to make mathematics more relevant to learners but how appropriate are these contexts to the learners? Sometimes contexts bear little or no relation to the mathematics being taught but by engaging learners in such activities convinces them that they are relevant to them and associated with the real world. The relevance of such contexts is what William (1997) refers to as a Macguffin, a metaphor used by Alfred Hitchcock to describe a plot device used to motivate action in a film and to which little attention is paid. "Often children are not expected to treat these problems as real. Instead they either have to ignore real world considerations, or introduce just a very well-judged small dose" (Cooper, 2001, p.256).

du Feu (2001) described five different types of contexts: Context-free, Real, Cleaned, Parable and Contrived. Context-free includes everything from simple equations to long multifaceted proofs. The question is not set in context, although some may argue that they are real contexts where the context is mathematical. Real contexts are contexts with real world problems. Real world problems can be solved by modelling them in mathematical terms. Many of these are statistical in nature, where the sources of data are given. Cleaned contexts are simplified versions of real contexts. The contexts are simplified in order to make the question accessible to learners and/or in the time constraints of examinations. Fictitious contexts attributed to an unnamed anonymous person/company/organisation, etc. are referred to as parables. Here the situation is fictitious and its function is to make some point, namely to teach or test mathematics. Contrived contexts are contexts that are invented to fit a particular mathematical point, irrespective of how appropriate these situations are to real life. These contexts may have been inspired by a real situation but the connection with reality has been lost.

In his analysis of the 2008 Grade 12 Mathematical Literacy examinations, North (2010) found many of the contexts used were “pseudo-contexts” (p.12). They were contexts that were either artificially constructed, inappropriate to the mathematics being explored in that context, or recontextualised to draw focus away from the real-life and onto specific mathematical concepts. Pseudo-contextualisation, he argues, inhibits “mathematisation” since the contexts are inappropriate, unrealistic or artificial.
Usiskin (2001, in Frith and Prince, 2006) warns against the use of contrived ‘real life’ contexts masquerading as ‘reality’ in the mathematics classroom. In their study with in-service teachers, Frith and Prince (2006) found that when teachers designed a mathematical and statistical task (Data Handing) involving learner engagement with real and relevant contexts, the principles of critical thinking, communication, collaborative work, positive attitude and confidence were promoted.

Since learner engagement is a social practice involving not only what learners do but also the ideas, attitudes, ideologies and values that inform what they do (Frith & Prince, 2006, p.52), mathematical literacy tasks set in real contexts involves “linking practice and theory” (Graven & Venkat, 2008). In their study, Graven & Venkat (2008) showed how different teachers working with the same contextual task experienced different agendas in relation to the relationship between content and context. They identified a spectrum of four agendas: Context driven agenda, Context and content driven, mainly content driven and content driven. Context driven agendas explore contexts that the learners need in their lives, critically engaging in these contexts to extract the mathematics embedded in them. These contexts are the ‘real’ contexts described by du Feu. Content and Context driven agendas are in a dialectical relationship with each other and explore contexts to deepen understanding of not only the mathematics but also the contexts themselves. Mainly Content driven agendas involve learning mathematics and then applying it to various contexts. These are the 'cleaned' contexts described by du Feu, where real contexts are edited to enable their application to an appropriate level of learning. Content driven agendas are "context free" and used mainly for revision purposes such as revising fractions.

The manner in which learners approach assessment items embedded in 'realistic' contexts is related to their socio-cultural background (Cooper & Dunne, 1998). They argue that test items contextualising mathematical operations within 'realistic' settings might be expected to cause particular problems of interpretation for working class students, so much so that they perform significantly worse than their middle class peers on these tasks, whereas performance on decontextualized tasks is equivalent (Zevenbergen, et.al., 2002). Consequently, learners' actual existing capacities in mathematics are underestimated, and the degree of such underestimation varies by social class. Ahmed & Pollitt (2000) also explained that students react in an individual and unpredictable way to different contexts, and schemas provoked by contexts can interfere with those provoked by the science content of questions, causing misunderstandings and errors.

Putting questions into context inevitably involves using extra words to ask the question. If learners have to read more text in order to answer questions, then their reading ability is being tested as well as their understanding of mathematics (Ahmed & Pollitt, 2001). Language is often a barrier particularly to second language English learners dealing with contextually based questions. In their case study of a grade 9 CTA assessment task, which was grounded in 'real-life' context, Bansilal & Wallace (2008) found that learners' poor language skills acted as a barrier to understand the context of the task as well as to impede their understanding of the instructions. To further exacerbate the language barrier, many contexts are overloaded with information of explanations and descriptions. It was found that with an intertwining of 'context information' or information that is used to paint a picture about the context, and 'crucial information' or information necessary to solve the task, learners were not skilled enough to extract the crucial information necessary to solve the problem. Ahmed & Pollit (2001) suggested that to ensure validity of contextual questions in order to measure what we intend to measure, irrelevant information should be kept to a minimum.

A study by Dempster & Reddy (2007) has shown that sentence complexity influenced the performance of learners on TIMSS items, and the effect was more pronounced in learners with limited proficiency in English than learners who were more proficient in English. Ahmed & Pollitt (2000) suggest that the reading load can be reduced through the use of a picture or a diagram. However, they caution that students are likely to pay a great deal of attention to these pictures or diagrams and any irrelevant information pertaining to them may become distracters and result in responses based on the context rather than the content of the question. Fictional or unfamiliar contexts are likely to cause learners to mistakenly think they had never learnt the section of the work being tested and hence may make them skip the question. They are thus unable to transfer their knowledge from a different context.

Real-life contextually based questions often come with their own specialised language and complexities (Bansilal & Khan, 2009). The terminology of the context may involve vocabulary relating to adult concepts. Examples of these are '200 free kilometres' in car hire scenarios and 'base occupancy' in room bookings. Often these specialised languages are beyond the learners' experience. Boaler (1993) pointed out the importance of avoiding 'adult metaphors' such as wage slips and household bills.

2.1.4 Design of Assessment Tasks in Mathematical Literacy

The Subject Assessment Guidelines for Mathematical Literacy (DoE, 2008) provide the following motivation for Mathematical Literacy:

> *The competencies developed through Mathematical Literacy are those that are needed by individuals to make sense of, participate in and contribute to the twenty-first-century world — a world characterised by numbers, numerically based arguments and data represented and misrepresented in a number of different ways. Such competencies include the ability to reason, make decisions, solve problems, manage resources, interpret information, schedule events and use and apply technology, to name but a few* (p.7).

To develop these competencies, the document suggests that learners be exposed to both mathematical content and real-life contexts.

> *Assessment tasks should be contextually based, that is, based in real-life contexts and use real-life data, and should require learners to select and use appropriate mathematical content in order to complete the task. Some assessment tasks might more explicitly give learners the opportunity to demonstrate their ability to 'solve equations', 'plot points on the Cartesian plane' or 'calculate statistics such a mean, median and mode for different sets of data' while other assessment tasks might be less focused on specific mathematical content and rather draw on a range of content to solve a single problem.* (DoE, 2008, p.7).

Teachers need to design a program of assessment which includes tasks that provide learners with the opportunity to demonstrate both competence with mathematical content and the ability to make sense of real-life, everyday meaningful problems. As such, classroom assessments should include a wide range of options such as controlled (standardized) tests, assignments, investigations, research tasks, projects, interviews, case studies, and debates (DoE, 2005).

In order for assessments to be sound, they must be free of bias and distortion. Reliability and validity are two concepts that are important for defining and measuring bias and distortion in assessments. *Reliability* refers to "the degree to which test scores are free from errors of measurement" (American Educational Research Association, American Psychological Association, and National Council on Measurement in Education, 1995, p.8; cited in Killen, 2003, p.2). Arising from this definition, classroom tests and national standardized exams are reliable if they measure something consistently – it should not make any difference whether a student takes the assessment in the morning or afternoon, one day or the next. Another measure of reliability is the internal consistency of the items. If a student gets an item correct, you should be able to assume that he or she will also get other, similar items correct.

Reliability in itself, however, is not a sufficient condition for assessment to be accurate, worthwhile and trustworthy. An assessment task that consistently measures something that is unrelated to the task objective does not make it a trustworthy instrument to assess a learner's performance. Hence the need for an additional criterion of *validity* is required.

Validity refers to "whether a test or item measures whatever it has to measure" (Van der Horst & McDonald, 2001; cited in Killen, 2003, p.3).

If contexts are to be used to test students' understanding of real-world mathematics, careful consideration of appropriate contexts is necessary in order not to compromise validity. Ahmed & Pollitt (2000) found that in Science, questions containing contexts can make it more difficult to measure the students' level of understanding of the science involved since a context will have different effects on different students in terms of their familiarity, greater reading demands through extra words in contexts, and the amount of irrelevant information acting as distracters within the context. They advise that in order to ensure validity, we need to know that "students' minds are doing the things we want them to show us they can do" (Ahmed & Pollitt, 2001. p.13).

One important issue about reliability and validity is for assessment to test a range of cognitive levels. I am of the opinion that Bloom's Taxonomy, developed in the 1950s, remains one of the most universally applied models on the quality of human thinking, and the closest model to assess the Mathematical Literacy examination question paper. Bloom made "the improvement of student learning" (Forehand, 2010, p.2) the central focus of his life's work. Adapted for classroom use as a planning tool, Bloom's Taxonomy provides a way to organise thinking skills into six levels, from the most basic to the higher order levels of thinking. It goes from easy tasks such as recalling knowledge to more difficult tasks such as evaluating an argument. The term 'task' includes everything you ask students to do: verbal question and answer, tasks set in the lesson, and full blown assignments or projects. It also includes tasks for work inside and outside the class.

In the 1990s, Anderson (a former student of Bloom) revisited the taxonomy and made changes to the terminology from nouns to verbs, as the taxonomy requires different forms of thinking and thinking is an active process. 'Knowledge' being a product of thinking was replaced with the word 'remembering'. 'Comprehension' became 'understanding' and 'synthesis' was renamed 'creating' in order to better reflect the nature of the thinking described by each category. The structure of the taxonomy was also changed with 'Create' assuming the highest (i.e. most complex, most abstract) position on the Cognitive Process Dimension above Evaluate.

The diagram below shows Bloom's new revised cognitive dimension.

Figure 1: The new revised Bloom's Cognitive Taxonomy.

Structural changes of Bloom's taxonomy involved the addition of a knowledge dimension. Four types of knowledge were recognised: Factual, Conceptual, Procedural and Metacognitive. The model then changed from a one-dimensional form to a two-dimensional form. The intersection of the Knowledge Dimension (or the kind of knowledge to be learned) and the Cognitive Process Dimension (or the process used to learn) gave rise to twenty-four cells.

There has been recent interest and debate in South Africa about the levels at which assessment tasks in Mathematics and Mathematical Literacy are pitched (Venkat, Graven, Lampen & Nalube, 2009; Berger, Bowie & Nyaumwe, 2010). The Department of Education seems to have looked for a simpler taxonomy to Bloom's. The Programme for International Student Assessment Framework (PISA, OECD, 2003) provides a possible taxonomy for assessment of Mathematical Literacy based on what it calls competency clusters. The Trends in Mathematics and Sciences Study (TIMSS) Assessment Framework (IEA, 2001) provides another, based on cognitive domains. Drawing on these two very similar frameworks the following taxonomy for Mathematical Literacy is proposed by the Department of Education (DoE, SAG, 2008, p.8).

Level 1: Knowing
Level 2: Applying routine procedures in familiar contexts
Level 3: Applying multistep procedures in a variety of contexts
Level 4: Reasoning and reflecting.

The mathematical assessment taxonomy is linked to rating codes or marks for recording purposes. Table 1 shows how a weighting of the different kinds of tasks at each level of the taxonomy could correspond to the different rating codes.

<table>
<tr><th>RATING CODE</th><th>RATING</th><th>MARKS %</th><th colspan="4">MATHEMATICAL LITERACY ASSESSMENT TAXONOMY</th></tr>
<tr><td>7</td><td>Outstanding achievement</td><td>80 - 100</td><td></td><td></td><td></td><td rowspan="3">Reasoning and reflecting</td></tr>
<tr><td>6</td><td>Meritorious achievement</td><td>70 - 79</td><td></td><td></td><td rowspan="3">Applying multi-step procedures in a variety of contexts</td></tr>
<tr><td>5</td><td>Substantial achievement</td><td>60 - 69</td><td></td><td></td></tr>
<tr><td>4</td><td>Moderate achievement</td><td>50 - 59</td><td></td><td rowspan="3">Applying routine procedures in familiar contexts</td><td></td></tr>
<tr><td>3</td><td>Adequate achievement</td><td>40 - 49</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>Elementary achievement</td><td>30 - 39</td><td rowspan="2">Knowing</td><td></td><td></td></tr>
<tr><td>1</td><td>Not achieved</td><td>0 - 29</td><td></td><td></td><td></td></tr>
</table>

Table 1: Rating codes, marks and the mathematical literacy assessment taxonomy.
Source: Subject Assessment Guidelines: Mathematical Literacy – January 2008, p.9

Table 1 shows that a learner would not be able to achieve an Outstanding achievement rating code of 7 (80% – 100%) without having satisfied the requirements of the questions that are pitched at the reasoning and reflection level of the taxonomy. Similarly, Table 1 also illustrates that while it may be possible to achieve a sub-minimum of 25% based on tasks that require knowing alone, learners who are awarded an Adequate achievement rating (40% – 49%) also had to successfully complete some tasks pitched at the applying routine procedures in familiar contexts level of the taxonomy.

It must also be borne in mind that the formal assessment in the Grade 12 Mathematical Literacy examination consists of two papers. Both papers cover all four learning outcomes with equal weighting given to each. The difference in the two papers is in terms of the complexity and/or cognitive demands of the questions. Paper One is considered a "basic knowing and routine applications paper" (DoE, SAG, 2008, p.15). It consists of approximately 60% level one and 40% level two questions. Paper Two is considered an "applications, reasoning and reflecting" paper. It consists of predominantly level three and level four questions each making up approximately 40% with the balance of 20% for level 2 type questions.

Paper Two being an “applications” paper, requires a significant amount of problem solving as outlined in Level 4 – Reasoning and Reflecting type questions in the SAG document:

> Tasks at the reasoning and reflecting level of the Mathematical Literacy taxonomy require learners to:
>
> - Pose and answer questions about what mathematics they require to solve a problem and then to select and use that mathematical content.
> - Interpret the solution they determine to a problem in the context of the problem and where necessary to adjust the mathematical solution to make sense in the context.
>
> (DoE, SAG, 2008. p.28)

North (2010) found that only 10% of the 2008 examination question Paper Two (as opposed to the required 40%) were of Level 4 – Reasoning and Reflecting questions. He further found that of the small number of Level 4 questions present, these focused on giving an opinion or comparing two calculated values to make a decision, rather than on the process of mathematising. Venkat et.al. (2009) also analysed the 2008 examination question papers and similarly found that across both papers 60% of the marks could be obtained without any problem solving, hence making the validity of the question papers questionable. The problem, they argue, is not in the choice of the contexts but in the structure of the questions which is simplified through scaffolding as well as by aligning themselves to the taxonomy levels. Level 1 and level 2 of the taxonomy have no problem solving at all and hence Paper One has no problem solving as it addresses only level 1 and level 2 questions. The findings indicate that there is a need for greater problem solving and mathematising in the examination question papers in order to meet the competency requirements of what the curriculum describe as a mathematically literate person.

The process of mathematising is similar to the process of modeling real life problems in Mathematical Literacy. Mathematical modelling is a process of representing real world problems in mathematical terms in an attempt to find solutions to the problems. A mathematical model can be considered as a simplification or abstraction of a real world problem or scenario into a mathematical form, thereby converting the real problem into a mathematical problem. The mathematical problem can be solved using various known techniques to obtain a mathematical solution. This solution is then interpreted and translated back into real terms.

Alsina (2007) considers the real problem and the skills for deriving practical consequences as most important, since they provide motivation to the learner as to how mathematics is relevant to everyday life. Developing the five interwoven strands comprising of conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition, would help learners in deeper understanding of mathematics and the ability to use mathematics where it matters (Kilpatrick et.al., 2001). Mathematical models of authentic situations rather than artificial textbook problems help to achieve these competencies.

Muller & Burkhardt (2007) argue that to be effective, mathematics must be approached holistically rather than as an accumulation of bits and pieces of de-contextualized knowledge. "It is harder, not easier, to understand something broken down into all the precise little rules than to grasp it as a whole" (Thurston, 1990, quoted in Muller & Burkhardt, 2007, p.269). Thus contextually based mathematical modeling provides ideal settings to blend content and process to produce flexible mathematical competence. Although connecting mathematics to authentic contexts helps make mathematics meaningful, it demands delicate balance. As will be seen in later chapters, contextual details camouflage broad patterns that are the essence of mathematics.

2.2 THEORETICAL FRAMEWORK FOR THE STUDY

In this section, I present a development of three key ideas which underpin this study. I first discuss some skills needed for mathematical literacy, before moving on to the theory of constructivism and then linking these to some complexities involved in the contextualisation of tasks.

In PISA's definition (OECD, 2003, p.24):

> *Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded mathematical judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.*

The above definition conveys three important ideas (Steen & Turner, 2007, p.286):

- mathematical literacy is much more than arithmetic or basic skills.
- mathematical literacy requires something quite different from traditional school mathematics, and
- mathematical literacy is inseparable from its contexts.

The third idea is of particular importance and is emphasised in the Department of Education's Subject Assessment Guideline for Mathematical Literacy (2008):

> *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, p.7).

It further states:

> *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. Learners should use mathematical content to solve problems that are contextually based (*DoE, 2008, p.7).

This suggests that assessment tasks should be contextually based, that is, based in real-life contexts and use real-life data, and should require learners to select and use appropriate mathematical content in order to complete the task. Competency in mathematical modelling helps one to tackle problems from the "real world". Steen & Turner (2007, p. 286) use the phrase "mathematics acting in the daily lives of citizens". The National Curriculum

Statement (DoE, 2006, p.42) requires the subject to be "rooted in the lives of the learners". This view is synonymous with the theory of Realistic Mathematics Education (RME) developed by the Freudenthal Institute in the Netherlands. Freudenthal made two important points, namely that RME must be close to children and be relevant to everyday life situations (Freudenthal, 1991).

The approach required to develop Mathematical Literacy is "to engage with contexts rather than applying mathematics already learned to the context" (DoE, 2003, p.42). RME claims that this can be achieved when mathematics is taught as a human activity instead of transmitting mathematics as a pre-determined system constructed by others. In RME, as with mathematical literacy, contextual problems are the basis for progressive mathematisation, and through mathematising, the students develop informal context-specific solutions strategies from experientially realistic situations (Gravemeijer & Doorman, 1999). The emphasis in the preceding sentence is on "experientially realistic situations". The context used in mathematical literacy has to be close to the learners experience for them to be meaningful.

The concept of mathematisation was extended by Treffers (1987, cited in Gravemeijer & Doorman, 1999, p.116), who made a distinction between horizontal and vertical mathematisation. In horizontal mathematisation, the students come up with mathematical tools which can help to organise and solve a problem located in a real-life situation. Vertical mathematisation is the process of reorganisation within the mathematical system itself, for instance, finding shortcuts and discovering connections between concepts and strategies and then applying these discoveries. In short, "horizontal mathematisation involves going from the world of life into the world of symbols, while vertical mathematisation means moving within the world of symbols" (Freudenthal, 1991, p.42).

In RME, applying mathematics is very difficult if taught 'vertically', that is, various subjects are taught separately (Lange, 1996). Curriculum 2005 also emphasised an integration of Learning Areas so that "learners experience the Learning Areas as linked and related" (DoE, 2002a, p.13). RME share many similarities with the theory of constructivism in Mathematical Literacy. Constructivism is a theory of learning which posits that students learn by actively constructing their own knowledge, knowledge is created not passively received and views learning as a social process (Clements & Battista, 1990).

Vygotsky (1962) promoted the view of learning based on both individual and social construction, and showed the importance of social interaction and language in supporting and extending learning. Initially, a child's new knowledge is interpsychological, meaning it is learned through interaction with others, on the social level. Later, this same knowledge becomes intrapsychological, meaning inside the child, and the new knowledge or skill is mastered on an individual level. The Mathematical Literacy classroom also emphasises the need to "work collaborately in teams and groups to enhance mathematical understanding" (DoE, 2003. p.10).

Constructivism argues that all knowledge is constructed by individuals rather than transferred directly by an expert, such as a teacher, parent or book, to the learner. The constructivist perspective argues that all knowledge is actively constructed by the learner. This means that that the learner plays the primary role in organising input from outside into meaningful knowledge. According to Epstein (2002), constructivism emphasises the importance of the knowledge, beliefs, and skills an individual brings to the experience of learning. It recognises the construction of new understanding as a combination of prior learning, new information, and readiness to learn.

Epstein (2002, p.3) offers a deeper insight into constructivism by identifying nine general principles of learning that are derived from constructivism. Of these nine principles, four are directly related to this study, and will be used to derive some of the categories that will be used in the analysis in Chapter Five.

- Learning involves language: the language that we use influences our learning.
- Learning is a social activity: our learning is intimately associated with our connection with other human beings, our teacher, our peers, our family, as well as casual acquaintances.
- Learning is contextual: we learn in relationship to what else we know, what we believe, our prejudices and our fears.
- One needs knowledge to learn: it is not possible to absorb new knowledge without having some structure developed from previous knowledge to build on.

The focus of this study is the learners' responses to contextualised test items in a Mathematical Literacy provincial examination. Language plays four important roles here.

Firstly the written context is a textual representation of a real life context, and cannot capture all the details of the context. Thus it may convey a limited representation of the real context. Secondly, putting questions into context inevitably involves using additional words to ask the question. If learners have to negotiate more textual information in order to answer questions, then their reading ability is being tested as well as their understanding of mathematics (Ahmed & Pollitt, 2001). Language can thus be a barrier to particularly second language English learners when dealing with contextually based questions. Thirdly, the language used in the assessment tool influences the ways in which the learners respond to the items. Sometimes learners may misinterpret instructions which are not clearly and unambiguously framed. They may provide a response different to what the examiner expects because their interpretation of the question was different from what the examiner intended. Fourthly, language also plays a role in the assessment of the learners' responses. Learners who struggle with writing or speaking English may be disadvantaged by questions which require much explanations, reflections or reasons.

The principle that learning is a social activity has applicability to this study because learners learn from their peers as well as their family and teachers. All these encounters contribute to the ways in which learners' knowledge develops.

The third principle that learning is contextual has particular significance to this study. The context here has various interpretations. It refers to the context in which learning takes place, such as the classroom, the home or environment. However, we can also interpret it as the context that is used as a setting for instruction or assessment. In the case of Mathematical Literacy, the DoE advise that context and context should be intertwined:

> *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. Learners should use mathematical content to solve problems that are contextually based (*DoE, 2008, p7).

Bernstein (1996) argues that the process of recontextualisation whereby school mathematics is being recontextualised into another field – in this case the everyday – creates a new set of demands previously not recognised. Both teachers and learners will need to acquire new recognition rules and new realisation rules. Recognition rules are the means by which individuals are able to recognise the speciality of the contexts in which they are. Realisations rules determine *how* we put meanings together and *how* we make them public i.e. allowing the production of 'legitimate text'.

Many teachers of Mathematical Literacy comment that learners with a good command of the English language, greater exposure to everyday experiences and from schools situated in higher socio-economic suburbs generally perform better than, for example, English second language learners, coming from low socio-economic areas with limited everyday experiences. This may be related to the way learners interpret questions in mathematical literacy, where learners from lower socio-economic backgrounds using real life experiences in making sense of the questions. Bernstein's theory would attribute this phenomenon to such learners not acquiring the recognition and realisation rules. The current study will look for such patterns when examining learners' responses to context-based questions.

Real-life context based tasks often come with their own specialised language and complexities (Bansilal & Khan, 2009). The terminology of the context may involve vocabulary relating to adult concepts. As mentioned, examples of these are '200 free kilometres' in car hire scenarios and 'base occupancy' in room bookings, or in the case of this provincial examination, 'infant mortality rate' in the context of infant deaths (Q 4.2 of the examination paper) and 'win by a margin of…' in the context of soccer goals (Q2.2). Assessment using contexualised items often requires learners to recognise and distinguish between context information and crucial information, where crucial information refers to information without which the task cannot be solved, while context information refers to facts or information about the context, which may be disregarded in the solution of the task (Bansilal & Wallace, 2008). Sometimes there are context-specific rules, bound to the context that needs to be interpreted by the learner, for example, working out the transfer duty of a house. Examples in this study are working out the costs of various transactions from a bank from Q3.3, as well as the FIFA and fanatics scoring systems presented in Q 2.2 of the examination paper.

The fourth principle that learning is built on previous knowledge is also relevant to the study. One implication of this is that all learners' previous encounters with particular contexts will affect their perception and understanding of contexts that are used for instructional or assessment purposes. Thus it will be of value to investigate learners' perceptions and experiences of contexts used in the examination paper to identify ways in which their perceptions may influence their responses.

An important consideration in learning new knowledge is the organisation of knowledge and making connections with other concepts. Mathematical proficiency described by Kilpatrick, Swafford & Findell (2001) is made up of five interwoven strands. Of interest in this study is the strand of Conceptual Understanding, which refers "to an integrated and functional grasp of mathematical ideas. Students with conceptual understanding know more than isolated facts and methods. They understand why a mathematical idea is important and the kinds of contexts in which is it useful. They have organised their knowledge into a coherent whole, which enables them to learn new ideas by connecting those ideas to what they already know" (Kilpatrick et al., 2001, p.118).

The fourth principle also helps explains what may happen when learners' new knowledge does not fit in with accepted mathematical traditions. As part of the normal process of constructing knowledge, learners often develop misconceptions. Brodie & Berger (2010, p.169) cite theories by Confrey (1990); Nesher (1987) and Smith, DiSessa & Roschelle (1993) to elaborate that a misconception is a "conceptual structure by the learner, which makes sense in relation to her/his current knowledge, but is not aligned with conventional mathematical knowledge."

2.3 SUMMARY

In this chapter I have outlined some literature relating to the background of Mathematical Literacy in South Africa showing the transformation of the South African education system from the post apartheid era and the placement of the present day Mathematical Literacy in the FET curriculum. Literature on the teaching, learning and assessment of Mathematical Literacy described mixed feelings of uncertainty and hope. Mathematical Literacy is embedded context. Learners should use mathematical content to solve problems that are contextually based. Assessment in Mathematical Literacy should reflect the interplay between content and context. This makes assessing Mathematical Literacy complicated.

What is real, everyday and relevant is dependent on things far more complicated than we know. Hence, the design of assessment tasks must be reliable and valid and must provide learners the opportunity to demonstrate both competence with Mathematical content and making sense of the world. Contexts must be carefully chosen and must be accessible to the learners to enable them to engage with the contexts and to mathematise it.

The theoretical framework that underpins this study is closely related to the idea of constructivism. Four principles derived from constructivism were shown to be directly related to this study. Language plays an important role in understanding the context. Learning is a social activity and helps learners built on existing knowledge. Previous knowledge and encounters with the contexts will affect learners' perceptions and understanding of the contexts. These principles guide the research questions that are enlisted in the chapter to follow.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter outlines the research methodology. It begins with the context within which this study was undertaken and an explanation of the process of the selection of the participants for this research. Thereafter, the aim of the research based on the critical questions as well as the qualitative research approach used to address these critical questions, is outlined. This is followed by the description of the methods used to collect the data. The validity and trustworthiness criteria suggested by Lincoln & Guba (1985) are then explained. The chapter concludes with an examination of the ethical issues involved, and the limitations of the study.

3.1 RESEARCH PURPOSE

The purpose of this research is to explore the learners' engagement with contextualised mathematical literacy examination tasks, thereby identifying factors which contributed to their success in these items. The September 2009 Preparatory Examination (Trial Examination) was used as the examination task (see Appendix A). The examination was set by the KZN Department of Education and was marked by the subject teacher of the institution and re-marked by the researcher in accordance to the marking memorandum provided by the KZN Department of Education. Four research questions have been posed.

Key research questions

1. What are the different types of contexts used in the Grade 12 Mathematical Literacy Trial Examination and how did learners perform in the different contexts?
2. How did learners' perceptions and experiences of the contexts influence their responses?
3. What are some strategies utilised by learners in these contextually based questions?
4. What are some factors that inhibited or promoted learners' success in these examination tasks?

3.2 RESEARCH PARADIGM

The research falls under the ambit of a mixed mode research paradigm. A paradigm is essentially a worldview, a whole framework of beliefs, values and methods within which

research takes place. It is this worldview within which researchers work. The study employed a mixed methods research design, with a quantitative analysis of learner's performance in the examination task based on gender and race (for language purpose), as well as performance based on the various types of contextual questions. The main purposes for the mixed methods design in this study were that of complementarity and development (Greene, Caracelli, & Graham, 1989). The complementarity aspect of the study refers to the elaboration, enhancement, illustration, and clarification of the results from one method with the results from the other method, while the development aspects refer to the use of the results from one method to help develop or inform the other method. The responses from the interview helped to develop and inform the performance of learners written responses to the variety of contexts identified in the examination task. In this study the qualitative component was designed to enhance and illustrate the nature of learners' perceptions and experiences and the strategies they used that determined their performance in the examination tasks.
The quantitative analysis was used to support the qualitative analysis based on learners' responses to the strategies used and their perceptions and experiences of the various types of contexts obtained during the interviews. The use of both approaches also enhances the integrity of findings.

The qualitative approach was suitable because of the nature of the research questions. Cresswell (2008) advises that in the qualitative approach, the research question should begin with a *how* or *what*. In this study three critical questions begin with *what* and one critical question begins with *how*. Although quantitative methods were used to answer the first research question, qualitative analytic procedures were used to provide answers to research questions 2, 3 and 4.

Cresswell (2008) recommends, a qualitative approach when the topic needs to be *explored* i.e. variables cannot be easily identified and theories are not available to explain the behaviour of participants. This research aims to explore the learners' engagement with tasks based on real-life contexts. Finally, qualitative research approaches are appropriate when studying individuals in their natural setting. Neuman (2011) also emphasises the importance of natural settings as opposed to contrived settings. This research studies learners in their natural setting, namely, the learners own school and the classroom. Lincoln & Guba (1985) claim that the naturalistic inquiry is probably the best instrument to use with human beings, as they (human beings) are receptive to environmental cues *[input]* and are able to interact with the environment and information within it simultaneously *[process]* and provide feedback, verify data and explore unexpected responses *[output]* (my italics). Merriam (1988) also emphasises the researcher as the primary instrument for data collection and data analysis in qualitative research.

By combining aspects of both qualitative and quantitative methods, I hoped to provide a more comprehensive account of the area of inquiry. The quantitative analysis provided an analysis of the variety of contexts in the examination task and the performance of learners in these contexts. The qualitative analysis provided the strategies used and the reasons for learners' success and failure in these contexts. Thus the strategy of using a mixed methods approach was to capture a holistic picture of the research setting.

3.3 CONTEXT OF THE STUDY

This study was conducted at a secondary school in Phoenix, North of Durban in the province of Kwa-Zulu Natal. The school was previously an all-Indian school with a current enrolment of 650 learners comprising 60% Indian and 40% African learners. The majority of learners reside in Phoenix and Amoati. There are between 45 and 50 learners per class in Grades 8 and 9, while in Grades 10, 11 and 12 there are between 35 and 40 learners per class. In total there are 17 class units. The school itself is 17 years old and is reasonably well maintained. The school has a library which is dysfunctional due to the unavailability of personnel. The school has a fully equipped computer laboratory sponsored by a Technology company as part of their community development project. The school fees have been fixed at R500 per learner for the past 3 years. Since learners came from low-income families, only about 50% of the school fees are recovered.

3.4 SELECTION OF THE SAMPLE

Being a teacher at the said school, I chose the school and participants through convenience sampling. All 73 Grades 12 learners from three class units were chosen. Convenience sampling is a type of non-probability, purposeful sampling where a group of people are chosen on the basis of being accessible (McMillan & Schumacher, 2010, p.137). "Information obtained from convenience sample [can] provide some fairly significant insights, and even could represent a useful source of data" in qualitative research (Passmore & Baker, 2005, p.51).

Stratified sampling (McMillan & Schumacher, 2010, p.134) was used to select the 10 learners to be interviewed for this study. The learners' total marks were recorded in a spreadsheet programme and sorted in descending order. Thereafter the sorted list was separated into males and females and Indian and African learners, giving a total of 4 groups with their total marks sorted in descending order. Three learners were chosen from each of the two larger groups and two learners were chosen from each of the two smaller groups given a total of 10 learners for the sample. The three learners from the larger groups were chosen from the top, middle and bottom of the list. The two learners from the smaller group were chosen from the upper half and the lower half. The sample therefore was representative of the population in terms of gender, race and ability.

3.5 DATA COLLECTION AND ANALYSIS

The data collection methods used in this study include document analysis of the learners written responses to the examination tasks, and interviews with 10 learners. A document analysis of the 2009 Preparatory Examination as well as the learner's written solutions were undertaken. The Individual semi-structured interview to probe strategies was the data gathering instrument for interviewing. Learners' strategies were grouped into each of the categories obtained through document analysis of the 2009 Preparatory Examination. This process is summarised in Table 3.1 below.

Research Question	**Data Collection Method**	**Purpose**
1. What were the different contexts used in the Mathematical Literacy Trial Examination for Grade 12 learners?	Document analysis of the Trial Examination question paper.	Group contextual questions into categories established du Feu (2001).
		Analyse the design of the examination tasks and the complexity of the scenarios.
2. How did learners' perceptions and experiences of the	Semi-structured interviews with ten learners.	Probe learners' understanding of the contexts and responses to questions on the Preparatory Examination.

contexts influence their responses?		
3. What strategies did learners utilise to solve problems set within the various types of contexts?	Document analysis of learners' written responses to the questions from the Preparatory Examination.	Identify strategies used by learners in solving contextually based questions which also assisted in conducting the Semi-structured interviews.
	Video recorded the semi-structured interviews with ten learners.	Probe learners' understanding of contexts and responses to questions on the Preparatory Examination.
4. What were some factors that promoted/retarded learners' success at problem solving?	Semi-structured interviews with ten learners	Probe understanding of contexts. Why learners responded the way they did.

Table 3.1: Four phases of the Design of the study

3.5.1 Document Analysis

The assessment instrument is critical in this study, and discussions of the tasks are intertwined in the analysis. To facilitate the analysis and discussion of the examination paper, I draw upon the revised Bloom's Taxonomy (Anderson, 2005) which describes the general format of assessment tasks given in the table below:

Introductory material		
1. Written	2. Pictoral	3. Real Object
Stem		
1. Question	2. Incomplete Statement	3 Directive
Response		
1. Short Answer Supply (fill in the blanks) Select (multiple choice) Matching / True-False	2. Extended Response Written Performance	

Table 3.2: The structure of Assessment Tasks
Source: Anderson, 2005, p.108

All assessment tasks are derived from the same blueprint, although not all tasks may include all three components. The three major components are the introductory material, the stem, and the response.

The **introductory material** gives the background to the question or some information on which the question is based. It may be some written text, a diagram or a real object. This forms the scenario in the mathematical literacy paper.

The **stem** is the actual task that the learners have to complete. It may be a question to answer, an incomplete sentence that they have to complete, or an instruction that they have to carry out.

The **response** is what the learners have to do to answer the question. The response may be short answers like choosing a missing word, choosing the correct answer in a multiple choice question, matching or true-false statements. The response may also be extended where learners have to write more than one word or perform some kind of action.

Anderson (2005) explains that not all assessment tasks include all three components. Assessing Remember and Factual Knowledge objectives may not include introductory material. Applying Procedural Knowledge often contains introductory material which provides the context within which the procedural knowledge is to be applied and provides information needed to apply the procedural knowledge.

A document analysis of the examination task was undertaken to critically look at the design of the tasks as well as to categorise the various types of contexts present in the examination paper. The analysis of documents is an invaluable source of information to qualitative researchers (Hoepfl, 1997). Cohen et al (2000) convey that content analysis could be used in the analysis of education documents. A document analysis of the Preparatory Examination was undertaken to assign categories to the variety of contexts in the question paper. The categories established by du Feu (2001) were used for this purpose. Feu categorised contexts into five different types: Context-free, Real, Cleaned, Parable and Contrived. The Curriculum and Policy Document (2010) emphasises that Mathematical Literacy involve real life contexts:

> *In exploring and solving real-world problems, it is essential that the contexts that learners are exposed to in this subject are authentic and relevant, and relate to daily life, the workplace and the wider social, political and global environments. Wherever possible, learners must be able to work with actual real-life problems and resources, rather than with problems developed around constructed, semi-real and/or fictitious scenarios. For example, learners must be exposed to real accounts containing complex and "messy" figures rather than contrived and constructed replicas containing only clean and rounded figures (DBE, 2010, P7).*

In light of this excerpt the researcher was interested in knowing what portion of the examination task was set in contexts and whether these contexts did in fact depict real life scenarios; hence the use of du Feu's categories for this purpose. Assigning categories to text portions is crucial for quantitative content analysis (Kohlbacher, 2006). A document analysis of the learners' written responses was also completed. With content analysis, the analysis of learner's written responses to the Preparatory Examination can "compare content across many texts" (Neuman, 2011, p.323). Thus the analysis of the Preparatory Examination could be compared to the analysis of learners' written responses to understand the strategies learners used to solve the different contextual questions.

3.5.2 Statistical Analysis of Students Responses

A statistical analysis of students' responses across all questions was undertaken to identify questions that learners found easy and difficult by categorising them in terms of learners attaining full marks, part marks or no marks for each question. The purpose of this analysis was to help me to compare performances between race and gender and hence to compare performances between English first language and English second language learners and between males and females. This analysis also guided my selection of a representative sample in terms of race, gender and performance. This analysis was also used to provide insight into the performance of learners across and within the different contexts.

3.5.3 Interviews

A research interview is defined by Cohen, Manion and Morrison (2000) as "a two person conversation initiated by the interviewer for the specific purpose of obtaining research relevant information" (p.269). Through interviews I was able to probe the thinking of the participants, and to extract participant's personal points of view regarding the strategies used to solve contextually based questions, which I was unable to 'see' through their written responses. This point is emphasised by Cohen et al (2000), when they state "one advantage of interviews is that it allows for greater depth than is the case with other methods of data collection" (p.269).

The interview is one of the most (if not *the* most) common research method in general and can be a rich source of information. Unfortunately there are also some dangers and pitfalls connected with interviews. There is always a danger of them becoming ordinary conversations without any desirable results. From a communication point of view there is a possibility that the interviewee does not give her/his actual opinions and ideas, but rather gives what s/he believes that he is expected to answer. Another drawback is that inexperienced interviewers may not be able to ask probing questions and hence some relevant data may not be gathered. In addition, inexperienced interviewers may not probe a situation. Despite these drawbacks, the interview as a data source has many advantages.

Some of the reasons why I chose the interview technique for this research are outlined by Anderson & Arsenault (1998, p.190).

> *People are more easily engaged in an interview than in completing a questionnaire. Thus, there are fewer problems with people failing to respond. Second, the interviewer can clarify questions and probe the answers of the respondent, providing more complete information than would be available in written form.*

The second point is especially important to me as the researcher. I wanted to use the interviews to complement and elucidate the participants' written responses to the Preparatory Examination and hence obtain a complete picture of how the participants dealt with and interacted with contextual questions. The purpose of the interviews was to probe the thoughts and ideas of the participants. I therefore chose the semi-structured interview as the most suitable for this purpose.

Semi-structured questions allow for interaction with the person, asking for details and clarification, but avoiding forcing the person in any direction, other than keeping their attention on the original topic (Boeree, 1998). Being semi-structured, additional questions can be asked that may not have been anticipated at the beginning of the interview. It allowed the researcher to explain or rephrase the questions if respondents are unclear, especially when interviewing English second language learners as was the case in this study.

Semi-structured interviews were chosen in order to allow the interviewees a degree of freedom to explain their thoughts and to highlight areas of particular interest and expertise that they felt they had, as well as to enable certain responses to be questioned in greater depth, and in particular to bring out and resolve apparent contradictions.

Interviews with the 10 participants took approximately an hour each. The 10 interviewees were asked the same questions that covered the entire question paper but each interviewee was probed differently in accordance with his/her responses to the questions. This required that ample time had to be set aside with minimal disruption during the interview and the participants' end of year study programme. The ten interviewees were interviewed individually in no particular order but rather when they became available. A secluded room in the computer laboratory was chosen to conduct the interviews. The room had been set up in advance with a video recorder and audio tape, a comfortable chair and desk, writing material, equipment, the 2009 Preparatory Examination question paper and the interviewee's written response to the examination paper.

Interviewees were given their answer papers to have in front of them while they talked. The purpose of the interviews was to find out the participants perceptions of the contexts used in the question paper and more about the strategies utilised by the students when answering contextually based questions. I was interested in explaining what may have led the participants to make certain mistakes and what led them to answer certain questions in a particular way.

Interviews were video recorded and later transcribed. Video recording was useful when the learner was asked to point to a given table or part of the given information where he or she looked for the crucial information needed to answer a question. Another advantage of video recording is permanence (DuFon, 2002), which allows for repeated viewing for a thorough analysis so that it can still be studied intensively.

The qualitative data analysis was done using inductive analytic processes. Initially a case of each learner was drawn up using the interviews and the learner's written responses to each of the questions. This was done for each of the 10 learners. The next step was to identify themes across the cases. There were 15 themes which emerged from the inductive analysis procedure. These were : Diagrams in contextual questions; Number Grabbing; Relevance of scenario; Adult related scenarios; Errors in question paper; Shortcoming of question paper; Complexity of scenario; Conceptual understanding; Misinterpretation of question/statement in question; Assumptions made by Learners; Crucial Information versus Context Information; Experiential Influence; Calculation error; Answers based on scenario and Language used in Mathematics Literacy. Thereafter, after much movement between the emerging themes and the original data, these were collapsed into three main overarching themes of Design of the tasks, learner's responses, perceptions and experiences of contexts. The 15 themes were then refined into 9 which were then categorized under these three themes.

3.6 VALIDITY AND TRUSTWORTHINESS

As with all forms of research, qualitative research has its limitations. One of the questions most often asked is, 'Will different observers get the same results?' Since qualitative research concerns itself with unique instances, the issue of repeatability is problematic. We all know that there is always more than one valid view in any social situation. People might agree on the facts of the situation but not on what they mean (Anderson & Arsenault, 1998, p. 133).

Guba & Lincoln (1981) state that all research must have "truth value"," applicability", "consistency", and "neutrality" in order to be considered worthwhile. To assure reliability in qualitative research, consideration of trustworthiness is essential. They proposed that the criteria in the qualitative paradigm to ensure trustworthiness are credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985).

The rigour in this research will be achieved by using the criteria suggested by Guba and Lincoln (1989, p. 233-241): "credibility, transferability, dependability and confirmability". It will address these criteria as indicated in the following table:

Strategy	Criteria	Application
Credibility	Triangulation. Interview techniques.	Participants' written responses to 2009 Preparatory Examination. Document analysis of 2009 Preparatory Examination, video recording of interviews.
Transferability	Dense description.	Verbatim quotes from interviews. Extracts of participants written responses to the 2009 Preparatory Examination.
Dependability	Dependability audit. Triangulation.	Semi-structured interviews, document analysis, written responses. Transcripts.
Confirmability	Triangulation Confirmability audit	Semi-structured interviews, document analysis, written responses. Transcripts to be checked.

Table 3.3: Criteria for trustworthiness in this research

It is acknowledged that no observations or interpretations are perfectly repeatable. In qualitative studies, it is believed that objective reality can never be captured (Denzin & Lincoln, 1998, p. 4). What is important when conducting qualitative research is to ensure traceability so that anyone can retrace the process:

> *The internal validity of qualitative research ... comes from keeping meticulous records of all sources of information used, using detailed transcripts, and taking field notes of all communications and reflective thinking activities during the research process* (Anderson & Arsenault, 1998, p. 134).

In this research every learner's written response to the 2009 Preparatory Examination is available. Also available is a copy of the question paper and marking memorandum; the marks obtained by each learner for each sub-question; an analysis of the number of learners who obtained full marks, part marks or no marks per sub-questions; a list of learners sorted according to marks obtained according to gender and race; an electronic copy of the video recording of the interviews, and the detailed transcripts of all ten interviewees.

There are various procedures when it comes to reducing the likelihood of misinterpretations in qualitative research.

> *To minimize the degree of specificity of certain methods to particular bodies of knowledge, a researcher can use two or more methods of data collection to test hypotheses and measure variables; this is the essence of triangulation* (Frankfort-Nachmias & Nachmias, 1996, p. 206, cited in Reidar Mosvold, 2005).

Triangulation is considered a way of using multiple sources to clarify meaning and to verify repeatability by identifying different ways the phenomenon is being seen (Stake, 1998).

> *...any finding or conclusion in a case study is likely to be much more convincing and accurate if it is based on several different sources of information, following a corroboratory model (*Yin, 1994, p.92).

This research used three different kinds of sources in triangulating the data: document analysis of the Preparatory Examination question paper, transcripts of the participant's interviews, and the learner's written responses to the question paper.

3.7 ANALYSIS OF DATA

The learners' papers were re-marked according to the original mark schemes for each question. Each learner's mark was recorded per question and sub-question to identify those questions which were problematic to learners and those that learners answered well. The transcripts from the interview with the ten selected learners were analysed. The learners' responses were sorted into broad themes. The results of these analyses will be quoted in the future chapters.

3.8 ETHICAL ISSUES OF THE STUDY

In any research, ethical issues needed to be recognised and addressed. A good qualitative study is one that has been conducted in an ethical manner, according to Merriam (2000, p.29):

> *...the validity and reliability of a study depend on the ethics of the researcher. It is ultimately up to the researcher to proceed in as ethically a manner as possible*.

Bearing in mind Bell's (1991) suggestions, an application was made to the University of Kwa-Zulu Natal, requesting permission to conduct this study. Upon receipt of ethical clearance (see Appendix B), the university made a request to the Department of Education, school principal, Head of Department, School Governing Body, and Parents of Learners involved in the study. Participants were ensured confidentiality and anonymity (initials of participants were used) and their participation were entirely voluntary, with the freedom to withdraw from the study if so inclined. The ten learners selected were informed about the process and purpose of the study. Learners were given the opportunity to asked questions to clarify any issues or uncertainties. Being minors, letters of consent were also signed by parents. The letters served to inform parents of the purpose of the study which would not interfere with their child's academic progress, as well as permission for learners to participate in the study and be interviewed and video recorded at an appropriate time.

3.9 LIMITATIONS OF STUDY

The sample in this study is small and inhibits the drawing of generalisations, which in any event, is not the main purpose of this mixed mode study. Convenience sampling was used in this study with my own learners as participants. Although the findings cannot be generalised to all learners in all schools, it will nevertheless highlight important implications for teaching and learning Mathematical Literacy. Being the respondent's teacher as well, may have influenced the participants' responses in terms of their anticipation of the responses I favoured, creating a degree of bias. The participants selected are from a particular school in a particular socio-economic area. Hence, the responses may be limited to a particular socio-economic group and cannot be generalised to other socio-economic groups of learners.

3.10 CHAPTER SUMMARY

In this chapter, an outline of the main aspects of the research methodology and corresponding paradigm were presented. Four research questions were outlined that guided the study. The research fell under a mixed mode paradigm; consisting of a quantitative analysis of the learners written responses and a document analysis of the Examination Task with the purpose of grouping the contexts into categories established by du Feu (2001). The quantitative analysis was used to support the qualitative analysis of the learners' responses during the semi-structured interviews. The data collection methods included a document analysis of the examination task, a document analysis of learner's written responses and semi-structured interviews with ten learners selected through stratified sampling. The data was analysed statistically in terms of contexts that learners found easy or difficult by categorising them according to the marks they obtained. Learners written responses were analysed and probed during the semi-structured interviews. Strategies for achieving the reliability and trustworthiness of the research were clarified by using triangulation through interviews, document analysis of student responses and document analysis of the examination task. Limitations to the study in terms of the small sample size and generalisation were outlined. The following chapter describes an overview of learners' performance in the examination.

CHAPTER 4

AN OVERVIEW OF LEARNERS' PERFORMANCE IN THE EXAMINATION

This chapter begins with the presentation of learners' marks per question followed by an analysis of their performance on the various questions embedded in context. A document analysis of the 2009 Trial Examination paper follows where questions are grouped according to the different types of contexts, and the performance within the contexts are analysed.

4.1 RE-MARKING OF LEARNERS SCRIPTS AND RECORDING OF MARKS

The following table shows the composition of the 73 learners in terms of gender and race.

	Indian	African	Total
Males	21	8	29
Females	29	15	44
Total	50	23	73

Table 4. 1: Number of learners according to race and gender

The classification in terms of race in this study was purely to make a distinction between English first language and English second language learners to ensure consistency. Each learner's total score for this paper was converted to a percentage and then re-arranged in descending order according to gender and race. The five tables below indicate this information.

Table 4.2(a): Marks obtained by Female African Learners	
Initials	**Percentage**
PH*	56%
NT	49%
MZ	48%
MNi	45%
MW	40%
GN	39%
MT	32%
MNm*	29%
CS	27%
MB	27%
NNh	26%
NM	25%
HB	23%
MNe	16%
MMb	15%

Table 4.2(b): Marks obtained by Male African Learners	
Initials	**Percentage**
MSa*	60%
LM	52%
NB*	51%
NL	36%
HSi*	33%
SSb	33%
LL	27%
DN	21%

Table 4.2(c): Marks obtained by Female Indian Learners	
Initials	**Percentage**
NKa	71%
GCt	69%
MSe	69%
GS	68%
MD	66%
NNe	65%
KF*	63%
MP	63%
PL	63%
EF*	62%
PK	61%
BB	55%
CR	55%
NKe*	54%
SSa	51%
NNa	50%
PT	49%
EN	48%
BS	46%
VK	45%
SSh	40%
MRo	39%
VS	38%
HSh	31%
PSu	30%
MMe	27%
MRe	25%
NA	25%
PV	23%

Table 4.2(d): Marks obtained by Male Indian learners	
Initials	**Percentage**
KS	63%
MJ	63%
GY	61%
JN	59%
NNi	57%
SSi	55%
MJu	55%
MRm	53%
PD	53%
RN	50%
RP	49%
CE	47%
MA	44%
MS*	44%
GCa	38%
GR	35%
ML	34%
HN	33%
RT	24%
PSa	21%
BA*	10%

Table 4.2 (e): Marks obtained only by interviewed learners	
Initials	**Percentage**
PH	56%
MNm	29%
Msa	60%
NB	51%
Hsi	33%
KF	63%
EF	62%
Nke	54%
MS	44%
BA	10%

Tables 4.2 (a) – (d): Marks obtained by learners.
*Learners who were interviewed.
Table 4.2 (e): Marks obtained only by interviewed learners.

When the marks of all 73 learners were arranged in descending order, it was seen that the 14 highest marks were scored by Indian learners (19%) and of these 76% were females. Thereafter the marks obtained amongst Indian and African learners were somewhat evenly distributed. The sample for the interview (table 4.2(e)) was made up of students from each of the four groups represented in tables 4.2 (a) – (d) in a manner which allowed for representation across different achievement levels as well.

4.2 MARKS OBTAINED PER QUESTION

Each of the 73 learners' marks per sub-question were recorded in a spreadsheet to determine the questions where learners experienced most difficulty and those learners found easy. An analysis was also made of the percentage of learners who scored full marks, part marks and no marks for each question. The data is summarised in Tables 4.3(a) and 4.3(b) showing sub-questions which were answered the best (number of learners scoring full marks in descending order) and sub-questions which were answered the worst (number of learners scoring zero marks in descending order), respectively.

Question	% Zero Marks	% Part Marks	% Full Marks
2.2.1(a)	5	0	95
4.2.3	7	0	93
3.1.1	10	3	88
2.2.1(b)	15	0	85
4.1.5	15	7	78
5.1.1	22	0	78
1.2.1(a)	25	0	75
1.1.1	32	3	66
3.3.1	36	1	63
3.1.2	37	3	60
4.1.4(b)	25	19	56
1.2.2	36	11	53
2.1.4(b)	47	0	53
2.1.3	7	41	52
2.1.5	45	3	52
3.2.1	34	15	51
2.2.2(b)ii	49	1	49
1.3.3(b)	4	48	48
2.1.4(a)	56	0	44
1.1.2	59	0	41
1.3.1	37	22	41
2.2.2(a)	25	34	41
4.1.4(c)	40	22	38
2.2.2(b)i	62	1	37
4.1.1	63	0	37
3.3.3	32	33	36
1.3.2	40	27	33
5.1.2	66	1	33
5.3	52	15	33
3.1.3	25	44	32
3.3.2	45	26	29
1.2.1(b)	19	55	26
4.1.4(a)	66	11	23
4.2.4	44	33	23
1.1.3	27	52	21
1.3.3(a)	71	8	21
2.1.1	49	30	21
5.1.4	74	8	18
2.2.3(b)	38	45	16
2.2.3(a)	30	58	12
3.2.3(a)	88	0	12
2.1.2(b)	86	4	10
3.2.2	12	78	10
2.1.2(a)	86	5	8
3.2.3(b)	60	33	7
4.1.3	95	0	5
4.1.2	96	0	4
4.2.2	90	8	1
5.2	64	34	1
4.2.1	59	41	0
5.1.3	97	3	0

Table 4.3(a): Percentage of learners getting full marks in descending order.

Question	% Zero Marks	% Part Marks	% Full Marks
5.1.3	97	3	0
4.1.2	96	0	4
4.1.3	95	0	5
4.2.2	90	8	1
3.2.3(a)	88	0	12
2.1.2(a)	86	5	8
2.1.2(b)	86	4	10
5.1.4	74	8	18
1.3.3(a)	71	8	21
4.1.4(a)	66	11	23
5.1.2	66	1	33
5.2	64	34	1
4.1.1	63	0	37
2.2.2(b)i	62	1	37
3.2.3(b)	60	33	7
1.1.2	59	0	41
4.2.1	59	41	0
2.1.4(a)	56	0	44
5.3	52	15	33
2.1.1	49	30	21
2.2.2(b)ii	49	1	49
2.1.4(b)	47	0	53
2.1.5	45	3	52
3.3.2	45	26	29
4.2.4	44	33	23
1.3.2	40	27	33
4.1.4(c)	40	22	38
2.2.3(b)	38	45	16
1.3.1	37	22	41
3.1.2	37	3	60
1.2.2	36	11	53
3.3.1	36	1	63
3.2.1	34	15	51
1.1.1	32	3	66
3.3.3	32	33	36
2.2.3(a)	30	58	12
1.1.3	27	52	21
1.2.1(a)	25	0	75
2.2.2(a)	25	34	41
3.1.3	25	44	32
4.1.4(b)	25	19	56
5.1.1	22	0	78
1.2.1(b)	19	55	26
2.2.1(b)	15	0	85
4.1.5	15	7	78
3.2.2	12	78	10
3.1.1	10	3	88
2.1.3	7	41	52
4.2.3	7	0	93
2.2.1(a)	5	0	95
1.3.3(b)	4	48	48

Table 4.3(b): Percentage of learners getting zero marks in descending order.

Table 4.3 is arranged in two ways: Descending order of percentage getting full marks (4.3(a)) and descending order of percentage getting zero marks (4.3(b)) – note that the order of the questions differs in both these tables.

Table 4.3(a) shows that questions learners performed well in were questions 2.2.1(a); 2.2.1(b); 3.1.1 and 4.2.3. These questions were based on the contexts of scoring during the soccer world cup, ratios involving two boys looking after cows during their school holidays, and questions based on a table showing infant mortality over three years. The worst performing questions, as indicated in Table 4.3(b) were questions 5.1.3; 4.1.2; 4.1.3 and 4.2.2. These questions were based on the contexts comparing the purchase price of a CD/DVD player from three different stores offering different prices and discounts. What was quite apparent was the discrepancy in the performance of learners on questions based on the same context. For example, 93% of learner obtained full marks for question 4.2.3, while 90% obtained zero marks for question 4.2.2, even though these questions were based on the same context of infant mortality. This implies that there must be some other factor(s) which must be influencing learner performance other than the context in which the questions are set. An investigation of the two questions showed that question 4.2.2 involved applying a multi-step procedure (Level 3), making use of the answer obtained from question 4.2.1 and hence making it a higher level question in the taxonomy than 4.2.3. The phrasing and setting of question 4.2.2 was also not clear. No reference was made in the question whether the probability needed to be worked out on the total number of deaths due to HIV *in comparison to all other types of deaths* or whether the probability needed to be worked out on the total number of deaths due to HIV *in comparison to the total number of live births*. This confusion led many learners to calculate the probability based on the former and deriving a response of 5 out of 8.8 (0.56) rather than the intended response of 90 deaths due to HIV out of 18 000 live births (0.005). Further details will be provided in Chapter 5.

Questions 1.2.1 (a) and 1.2.1 (b) were based on finding the circumference and surface area of a nut, respectively. 75% of learners were able to obtain full marks for the former question and 26% of learners were able to obtain full marks for the latter question, yet both questions were embedded in the same context of a socket (nut). Although the formulae for the circumference and surface area were given, the discrepancy in learners performance in both these questions was apparent. In question 1.2.1(a) the dimension of the nut was given in the question and learners had to simply substitute it and obtain the answer. In question 1.2.1(b) the dimensions had to be extracted from a 3-part diagram of the socket containing many dimensions. The complexity of the diagram may have confused learners who chose the incorrect dimensions to substitute into the formula. The fact that 55% of learners obtained part marks for question 1.2.1(b) shows that there were other factors apart from the context which impeded their performance.

Question 2.2 was based on the context of the soccer World Cup, an event familiar to many learners and set at an appropriate time when South Africa was chosen to host the 2010 event. Learners were presented with the results from four matches and in 2.2.1 (a) and 2.2.1 (b) were asked to calculate the points the teams would get from a partially completed table. 95% and 85% of learners obtained full marks respectively. The success may be attributed to the familiarity of the context. However, when additional details were added to the context in terms of another method of scoring by fanatics which includes bonus points based on the goal differences between teams, the performance on questions 2.2.2(a); 2.2.2 (b)(i) and 2.2.2(b)(ii) dropped drastically with 41%; 37% and 49% of learners obtaining full marks respectively. The lower performance may be attributed to the complexity of the scenario as well as the unfamiliarity of the new type of scoring introduced into the question.

Question 3.1 used the context of two school boys earning pocket money during the school vacation by working on a farm looking after animals. Question 3.1.1 asked learners to work out how much one of the boys would earn for looking after one animal, and question 3.1.3 required learners to use equivalent ratios to work out whether the two boys earned the same or different amount. Learners' performance on the latter question was worse (32%) than their performance on the former question (88%). The difference in performance on these questions based on the same context can be attributed to the cognitive level of the questions with question 3.1.1 assuming the basic level of 'knowing' and question 3.1.3 characterised by the cognitive level of 'applying routine procedures in a familiar context'.

The discussion and results in this section show that first language English speakers performed better than their second language English counterparts. It was also pointed out that with some contexts performances varied within the same context. I argue that some of the differences were because of the cognitive level of the questions, the diagram complexity, complexity of the context and the instructions of the task itself. I will now analyse the actual examination paper in terms of context to examine whether performance varied across the different contexts.

4.3 DOCUMENT ANALYSIS OF THE 2009 GRADE 12 TRIAL EXAMINATION PAPER TWO IN TERMS OF THE TYPES OF CONTEXT

The contexts used in the 2009 Trial Examination Paper (see Appendix A) were classified according to different types of contexts guided by the work of du Feu (2001), who grouped contexts into five types: Context-free, Real, Cleaned, Parable and Contrived.

Context-Free problems are based on questions involving simple equations and one-step arithmetic with no context. Real Contexts are based on questions involving real context with real problems. When there is reference to any named individual, institution, artifacts, organisms or products, these are considered real contexts. These contexts are mainly statistical in nature where the data used are quoted and the source acknowledged. Cleaned Contexts are real contexts but simplified to make question accessible to the user or in the time constraints of an examination. Parables are fictitious contexts attributed to an unnamed anonymous person/company/ organism. Their function is to make some point, for example, to teach or test some mathematics. Contrived Contexts are contexts that are invented to fit a particular mathematical point, irrespective of how appropriate these situations are to real life.

	Question No.	Type of Context	Context	Allocated Marks	Percentage of learners who obtained Full, Zero or Part Marks for each question.		
					Full Mark	Zero Mark	Part Mark
Trial 2009 Paper 2	1.1	Context Free	Conversions	8	42.5	39.3	18.3
	1.2.1	Context Free	Substitution into formula	6	50.7	21.9	27.4
	1.2.2	Context Free	Number of tins of paint needed	4	53.4	35.6	11.0
	1.3	Parable	Wages, UIF, sick leave, etc.	13	35.6	38.0	26.4
	2.1	Cleaned	Soccer World cup	22	34.2	53.8	11.9
	2.2	Cleaned	Scoring during world cup	17	47.9	32.1	20.0
	3.1	Contrived	Looking after cows on farm	7	59.8	23.7	16.4
	3.2	Contrived	Milking cows	13	19.9	48.6	31.5
	3.3	Parable	Bank accounts	10	42.5	37.4	20.1
	4.1	Real	Growth Chart	18	34.6	56.9	8.4
	4.2	Cleaned	Infant Mortality	13	29.5	50.0	20.5
	5.1	Contrived	Buying CDs	11	32.2	64.7	3.1
	5.2	Contrived	Compound interest	5	1.4	64.4	34.2
	5.3	Parable	Scale Drawing	3	32.9	52.1	15.1

Table 4.4(a): Performance based on various types of contextual questions

The table below summarises the data from the above table.

Type of Contexts	Mark Allocated	% of total	% with full marks	% with zero marks	% with part marks
Context Free	18	12%	48.9	32.3	18.9
Real	18	12%	34.6	56.9	8.4
Cleaned	52	34.7%	37.2	45.3	17.5
Parable	26	17.3%	37.0	42.5	20.5
Contrived	36	24%	28.3	50.4	21.3
TOTAL	**150**	**100%**	**37.2%**	**45.5%**	**17.3%**

Table 4.4(b): Summary of performance based on types of contextual questions.

In classifying the contexts as one of the five types, I discovered that it is not always a clear-cut process. For each of these categories, I discuss some considerations when doing the classification.

Context Free:

Although question 1 began with a scenario, question 1.1 did not require the scenario to perform the conversions. Hence, I classified question 1.1 as context free.

Real:

Real contexts should have a source or the source should be able to be found. I classified question 4.1 as real, as it was based on the growth chart. Although the source was not acknowledged, the chart itself is real and is provided by clinics and hospitals. It belonged to a child called Peter Brown who is a fictitious person. Nevertheless, the chart itself was real.

Cleaned:

Questions 2.1; 2.2 and 4.2 were classified as a cleaned context. Question 2.1 was based on the scenario of the soccer World Cup. The 2010 World Cup was a real phenomenon in South Africa at the time. Stadiums were being built, workers were being employed to build the stadiums, and target dates for completion were set. However, the number of workers required to complete the stadium may be questionable. Therefore I classified this scenario as a cleaned context.

Question 2.2 dealt with matches played, goals scored and the log table. It is true that in the World Cup round robins are played before the knockout stages. It is true that teams are awarded 3 points for a win, 1 for a draw and zero for a loss. These are real. However, the teams who are playing each other and the goals scored are invented. The proposed scoring by the fanatics is invented but NOT inappropriate to the scenario. I therefore classified this question as a cleaned context.

Question 4.2 dealt with statistics on infant mortality between 2004 and 2008 due to different illnesses. Had a source been acknowledged, the context could have been a real context. Nevertheless the context is a real situation in South Africa with a high rate of infant mortality as well as HIV/Aids, Polio, Measles and Hep-B. The actual number of babies who died, however, cannot be confirmed without a source. Hence I classified it as a cleaned context.

Parable:

Questions 1.3; 3.3 and 5.3 were classified as parables. Question 1.3 is a fictitious context. A worker, John had been invented. He worked for an unnamed employer and earned an amount that had been made up in order to test some mathematics, particularly percentages.

Question 3.3 centres on the context of a bank (Standard Bank) that offers two types of accounts (SUM[1] and ACHEIVER), and their respective fee structure in tabular form. The fee structure is not real and therefore cannot be a real context. The achiever account, for example, offers free deposits and withdrawals yet the context indicates otherwise. Thus the context is fictitious with the intent of testing the percentage of an amount and manipulating transactions.

Contrived:

Questions 3.1; 3.2; 5.1 and 5.2 were classifies as contrived contexts. Question 3.1 was based on a contrived scenario about Sipho and Themba looking after cows on a farm and earning pocket money. The context has been invented to test aspects of ratio in mathematics.

Question 3.2 is an extension of the scenario in 3.1, with Themba having to milk 10 cows and carry and empty the bucket into a bigger container in the farmer's house. The time taken to milk the cow is invented, the dimensions of the bucket is invented to test capacity and volume. I therefore classified this question as contrived.

Questions 5.1 and 5.2 are about deciding to buy CDs at three possible shops as well as investing money to buy a CD player. Both these questions are contrived. The names of the shops are invented and so too are the prices of CD players and the discounts on them. The amount received by the younger brother for passing Grade 10 was invented, as well as the number of years invested. The contrived context functioned to test percentages, discounts, and compound interest. I classified these questions as contrived contexts.

More than a third of the examination paper comprised of cleaned contexts. Context free question and real context questions were at a minimum, with each comprising 12% of the paper. It is understandable that context free questions should be at a minimum since this is the second paper in mathematical literacy. Questions in the second paper comprise more of levels 3 and 4 questions with very few level 1 and 2 questions, which are allocated to paper 1. Twenty-four percent of the paper is based on contrived contexts with the remaining 17.3% parables.

Detailed marking of the learners' scripts indicates that learners performed best when questions were not embedded in a context. The worst performance involved contexts that were real, with 56.9% of learners not being able to score any marks. Contrived contexts also posed problems to learners with only 28% of learners being able to score full marks. It is possible that learners were not able to relate to questions that were made up and that they had no meaning for them. Almost 40% of learners were able to score full marks with respect to cleaned contexts, perhaps because the contexts were cleaned so that the questions became accessible to the learners in terms of the language used, the figures given and the provision of additional information such as formulae. Another reason in this case could be that these contexts were based on real events (the World Cup and infant mortality), and hence learners are able to relate to them. Very few learners (8.4%) scored part marks for questions based on real context (most either got full marks or zero), indicating that when it came to questions based on real contexts, learners either understood them or were not able to understand these questions at all. To establish when language was a determining factor for success in questions rooted in real context, I attempted to compare the performance in question 4.1 (classified as real context) across English first and English second language learners, reflected in the table below as a percentage of the class.

To examine the language issue, I thought I would first compare the performance of English First and Second language learners across all the questions and thereafter look at question 4.1, which I classified as real-life context, in isolation. Since Paper 2 consisted predominantly of questions embedded in context, I compared the final average mark obtained by English First and Second language learners. The table below summarises the information.

	English First Language Learners	English Second Language Learners
Female	50%	33%
Male	45%	39%
Total	48%	36%

Table 4.5: Average marks obtained by English First and Second Language males and females

An independent sample t-test was performed to compare the performance of the English first language (Indian) and second language (African) speakers. There was a statistically significant difference in scores between the Indian students (M= 47.98; SD= 4.91) and the African students (M =35.22; SD= 15.02), with $t(71) = -3.621$ and $p = 0.01$, two–tailed with both English First language males and females performed significantly better than their English Second language peers in the examination task. The fact that the total average of English First language learners was 48% means that they also must have struggled with the questions in the examination task. A qualitative analysis based on the learners' responses in their answer scripts and the subsequent interviews (presented in Chapter 5), will perhaps elucidate this aspect.

The table below summarises the performance of learners in Q4.1 according to whether English is a first or second language.

	% with full marks	% with zero marks	% with part marks
English First Language (Indians)	35.7	54.0	10.3
English Second Language (Africans)	32.3	63.4	4.3

Table 4.6: Average Performance of English First and Second language learners on questions based on real contexts.

The above table shows no significant difference between English First and English Second language learners who obtained full marks for this particular contextually based question, implying that language was not a barrier to learners who "understood" the context. It would be interesting to know how many of the 32.3% of English second language learners, who obtained full marks in the real-life contextually based questions, had studied in an English medium school from inception, and thus had a better command of the English language, compared with the 63.4% of English second language learners who scored zero.

4.4 CHAPTER SUMMARY

Document analysis of the 2009 Trial Examination question paper indicates a small percentage of questions are designed around real-life contexts. Most of the contexts used in the question paper are cleaned or contrived. An analysis of learners answer scripts indicates that in most cases, there were other factors besides the context which affected learners' performance. The following chapter analyses learners' responses to the examination task which may shed light on the strategies used by learners in responding to the examination task and their perceptions and experiences of the various types of contexts which may promote or inhibit their success in these examination tasks.

CHAPTER 5

ANALYSIS OF THE INTERVIEWS AND LEARNERS' RESPONSES TO THE EXAMINATION TASKS

Data from 3 sources (the interviews with the 10 participants, the learners' responses to the examination tasks, and, the actual tasks themselves) were analysed with the purpose of trying to gain insight into the research questions. The three overarching themes that emerged from this process of analysis are presented in this chapter. These are:

1. The design of the task,
2. Strategies used by learners' in responding to the examination tasks, and
3. Learners' perceptions and experiences of the various contexts.

The words participants and respondents are used interchangeably to refer to those ten learners who were interviewed. Thus P4, refers to Participant 4 etc.

5.1 DESIGN OF THE EXAMINATION TASKS

In designing tasks which satisfy the mandate of Mathematical Literacy (ML), a task designer faces many challenges. Some challenges relate to the translation of real life contexts into textual representations which can be used for assessment purpose, while others are linked to clarity of instructions, and provision of crucial information. Under this theme, I identify two issues related to the actual design of the task.

5.1.1 Role of Diagrams

The diagrams in some questions did not help to elucidate the scenario. Poorly constructed diagrams or diagrams that are not fully thought out can confuse learners rather than aid them in the understanding of the question/scenario. This is the case with the diagram of a socket given in the Examination Paper. The diagram represented a socket in three parts each with its own dimensions: a diagram showing the whole socket, another showing the square hole on the top and another diagram showing the round hole at the bottom. Here is a reproduction of the diagram.

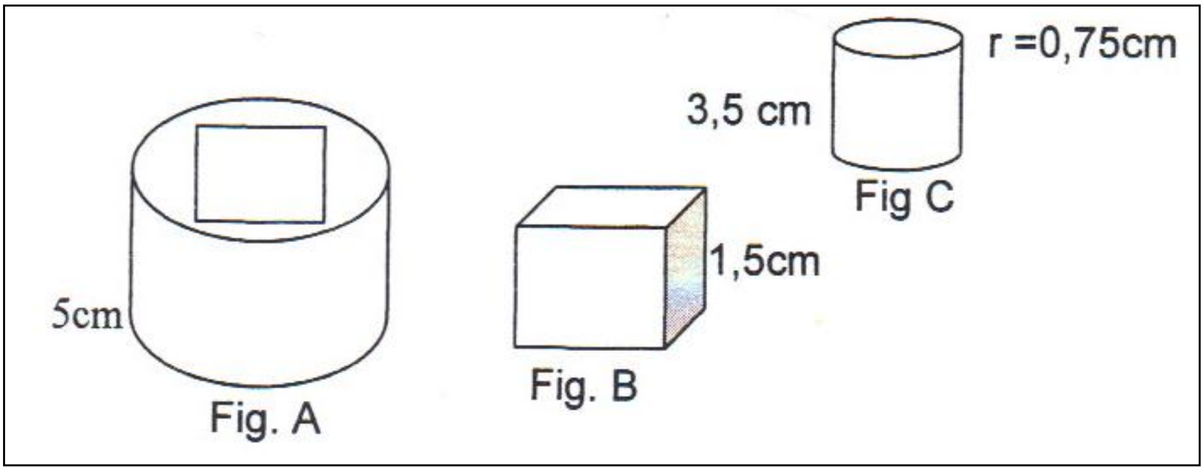


Figure 2: Three-part diagram of the socket

It is pertinent to note that 23 learners read the height of the socket as 3.5 which was the height of the circular hole in Figure C. One reason could be that they mistook Fig C for the whole socket, because these learners understood that d = 1.5, r = 0.75 and h = 3.5, which were the dimensions of the cylindrical hole. In fact P10, when asked, identified Fig. C as the whole socket:

T: Which did you think is the socket? Which is the whole socket?

L: Whole socket?

T: Ja.

L: This one here [Figure C] because this is the breakdown of this.

Many learners remarked in the interview that they were confused with the 3 diagrams. In explaining his confusion, P9 said that he clearly understood what a socket was and knew that it fitted into a ratchet. When asked what the height was, P9 identified the correct height in the interview:

T: What was the height?

L: The height was 5cm.

T: 5cm? Now look at question 1.2. Okay. You got….3.5 for your height.

L: Yah.

T: Where you got 3.5 from?

L: Ur…I took it from here (points to diagram showing circular hole of nut).

T: Okay. Where you suppose to have taken it from?

L: From here (Points to diagram of whole nut)

I then probed him to find out why he used the wrong measurement for the height of the socket in his examination response, even though he was able to identify the correct measurement during the interview. P9 replied: "*Aye, sir. I was …aye sir, I was like … what can you say… I was just writing what I know is right is right and carried on going.*" Then he added: "*Yah, there was like too much measurements to deal with…*" and also said "*…in like…what can I say…in like that one particular question there…it was like too much to analyse.*" This shows that P9 was confused with the diagrams and just took a measurement so that he could "carry on going".

Participant 10 has a friend who is a panel beater and he admitted seeing a socket at his friend's house. The learner however said that the diagram of the socket given in the paper was very confusing and did not look like what he thought was a socket.

L: Ja, I know a socket but when it's drawn up like this it doesn't seem…but I know a socket.
T: You know how it looks?
L: Ya, I know how it looks.

He later remarked that the diagram was confusing, because he did not know what the different measurements were. P10 also said that the diagram was not useful in finding the circumference of the socket since the diameter was given in question 1.2.1(a), but he needed to refer to the diagram to find the height of the socket.

T: Okay where did you get the D [diameter] from?
L: The diameter?
T: Ja… without looking at the diagram.
L: Here [referring to question 1.2.1(a)]
T: And the H?
L: That's the problem, the H, I had to look here [pointing to the diagram].
T: So you had to look at the diagram?
L: Yes

He had to decide which height to use in the formula: the height of the circular part, the height of the square part or the height of the whole socket. This required the learner to understand what each part represented and how they made up the whole socket. With so many diagrams showing parts of a single socket, this in fact confused the learner. This learner read off the height of 1.5 from Fig. B, which showed the side of the cubic hole.

T: …and where's the H in the diagram, the height?
L: 1.5 [Figure B].
T: The height. What they want? The height of the socket!
L: Ja. 1.5.

Thus P10 just read off values in an isolated manner from the 3 figures without trying to see how they fitted together. In fact, there were 7 learners who took the height as 1.5 cm, as given in Fig. B, like P10, suggesting that they did not see how the three figures fitted together.

P6 did not seem to have seen a socket before, although she said she did see one on a car door. P6 thought that she did not need the diagram to calculate the circumference of the nut as the diameter and formula were given. At the end she conceded that she needed the diagram to work to find the height:

T …. if they did not give you the diagram would you still be able to work it out?
L: Yeah…
T: So you didn't need the diagram?
L: No.
T: Okay, what about the surface area? Is there anything you needed here (pointing at the diagram)…
L: Yes, the height.

P5 used a similar strategy. She said she knew what the diagram represented because her father was a mechanic and she had seen a socket like this before and knew what it was used for:

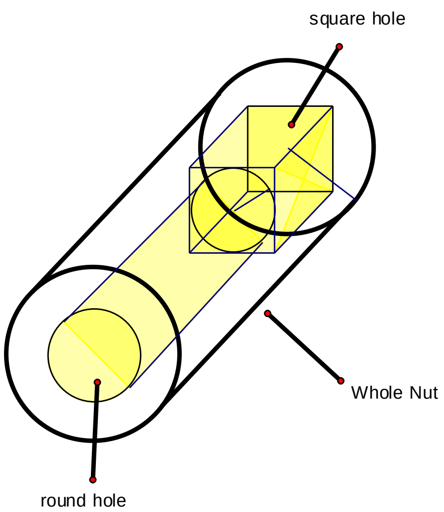
They normally use it in bolts and nuts of tyres, that's where I saw them using it in. It comes with a handle and it just fits in. They use it to open nuts on tyres.

Despite knowing what a socket looked like, she was still unable to extract the height of the socket from the diagram to calculate the surface area of the socket. The respondent did not know which height to select and incorrectly selected the height for the circular part of the socket (3.5 cm). All other substitutions into the formula were correct. The real thing and a diagrammatical representation of the socket made no difference to her understanding of the question.

There were 6 learners who read the value of the diameter as 5. This implies that they correctly identified Fig A as the whole figure but read off the height as the diameter because the illustration did not make it clear what the 5 cm stood for, and being placed at the bottom suggested to the learners that it could be the diameter. P10 indicated confusion about which value represented the height. Although he opted for 1.5 cm as the height, he said, "*Ja. 1.5. But I don't know about 5, why they put it over there.*"

His comment suggests that he was confused about whether the number 1.5 from Fig. B or the number 5 from Fig. A was the height of the socket. However, there were 60 learners who were able to correctly identify 0.75 as the value of *r*, revealing that there was less ambiguity about the information about *r*. This could be because *r* appears in Fig. C and was also given in the stem of Q1.2.1 (a). The reason why 23 learners read off the value 3.5cm for the height, as indicated at the beginning of this section, may be attributed to the fact that since learners used Fig. C to extract the radius, they assumed this to be the socket and hence used the height of Fig. C.

I suggest that a diagram like the one below, showing the structure of the nut would have been more helpful.



5.1.2 Errors or inconsistencies in the paper or marking memorandum

The examination paper was a provincial examination written by most Grade 12 Mathematical literacy learners. It is of concern that an analysis of the paper revealed that there were some errors or inconsistencies, or ambiguities in the questions and the marking memorandum that are discussed under this category. I discuss my concerns about Q4, Q4.1.2 and Q4.1.3.

Q 4.

The greatest concern here is the source document used, that seems to have been changed, and this has resulted in some inconsistencies and incorrect information being conveyed. The growth chart presented in this question contains 4 curves, the labels of which were very difficult to read. After much struggling, I deciphered the labels as "87th centile boys", "50th centile boys", "3rd centile girls" and "80% of expected weight girls". However, my reading could be wrong, because of the printing being smudged. The marking memo did not refer to the names of the graphs in the solutions, so there was no assistance from that source. In trying to interpret the meaning of these curves, I encountered a problem. There did not seem to be two different growth charts for girls and boys from birth to 2 years. Wagstaff & de Vries (1986), in describing their research of mothers' and nurses' understanding of weight/age growth charts, report that the growth chart in South Africa has growth channels on the 3rd, 50th and 97th percentile. They make no mention of different charts for boys and girls under the age of 2.

A second source, "The Road to Health Chart. Guidelines for Health Workers" (DoH, 2010), describes and displays a growth monitoring chart with 4 curves. The 4 curves are identical to the ones in the growth chart under review here, but are labeled 97th centile, 50th centile, 3rd centile and 60% of average weight. A third source (a growth chart for a child born 8 years ago) is similar to the two descriptions above. However, only for ages 2- 8 are there weight guidelines that differ for boys and girls. The conclusion is that the examiner either tweaked the chart so that she could pose questions about boys and girls, or she obtained an incorrectly drawn chart. In the process this rendered the chart more difficult to interpret and inconsistent. Furthermore, the information provided was insufficient to answer certain questions.

Q 4.1.2

This question asked for the "range of baby boys' masses at birth". The marking guideline gave the answer 4.5 - 2.2, where 4.5 was taken from the 1st (87th centile) and 2.2 from the 3rd graph (3rd centile girls), which makes no sense. However, the question itself cannot be answered from the information provided. What did the learners do when faced with the inconsistency? In fact, 96% of the learners did not produce the answer stipulated in the marking guidelines. Some learners (10) took the difference between the highest and lowest value on the "50th centile boys" graph and the "87th centile boys" graph (5 learners). Others (9) took the difference between the birth weights on these two graphs, which is understandable considering these were the only two graphs related to boys' weights. There were 13 learners who, like the examiner, considered the difference between the readings on the 1st (87th centile boys) and 3rd (3rd centile girls) graphs. Furthermore, information on the 1st curve (87th centile) was not clear. The beginning of the 1st curve provided in the growth chart was broken to insert the phrase "5kg". Many learners read off the beginning point as 5kg (there were 8 learners who referred to 5kg in their responses). In the interview, Respondent 5 understood the phrase 'range' but she explained that she selected the incorrect values. This was due to the line on the graph being obscured by the figure '5kg' with the respondent thinking that the line ends at 5kg; hence she selected 5kg as the highest value instead of 4.5kg where the line actually ends. The same learner selected 3.2 as the lower value for the range instead of 2.2 as required from the marking memo. The reason given for her choice was *"…because this two lines are boys. I looked at the boys lines not the girls. They talking about the boys".* The examiner by incorrectly including a curve for girls on Peter Brown's (a boy) growth chart, distracted learners, which explains the high percentage of learners (96%) failing to score any marks for this question on range.

Q 4.1.3

This question asked for the mass of a healthy 2 year-old girl who weighs 2.5 kg at birth. Here 95% of learners did not produce the suggested answer of 9.5 kg. However the answer 9.5 kg seems to have been read off the graph labeled 3rd centile **girls** (yes, the same graph which was used in Q4.1.2 to calculate the range of baby **boys'** masses). A 3rd centile graph means that 3% of all babies have weights below that curve and cannot be seen as the weight of a "healthy girl". The examiner, for Q4.1.1, used a 50th centile graph as a comparison for the weight of a normal boy. However, the tweaked chart now did not have a corresponding 50th centile curve to compare the weight of a normal girl. This is further evidence that the examiner was confused.

Furthermore, some information on the 3rd centile girls graph was not very clear. For Q 4.1.3, Respondent 5 chose 8.5kg instead of 9.5kg from the 3rd centile girls' graph. This was due to the fact that '1 to 2 YEARS' was written directly under 8.5kg and hence the learner thought that this was the weight for a 2 year old girl.

5.2 LEARNERS' RESPONSES

In an examination setting, the driving force is the desire to pass the assessment by providing responses judged to be what the examiner wants. So it is important to understand some of the reasons behind learners' responses. The themes here can be seen as learner factors linked to the learners' understanding of the mathematics concepts and the strategies that they used as they engaged with the tasks. Accordingly, under this theme I report on seven sub-themes (organised into two broad themes) that emerged from an analysis of the learners' responses to the test items as well as from the interviews. Many learners experienced challenges or barriers when trying to answer the examination tasks, three of which are covered under the heading "Constraints to some learners' success". Some learners resorted to using various strategies in order to arrive at their answers: four of these strategies are presented under the heading "Strategies employed by learners".

5.2.1 Some constraints to learners' success in the examination tasks

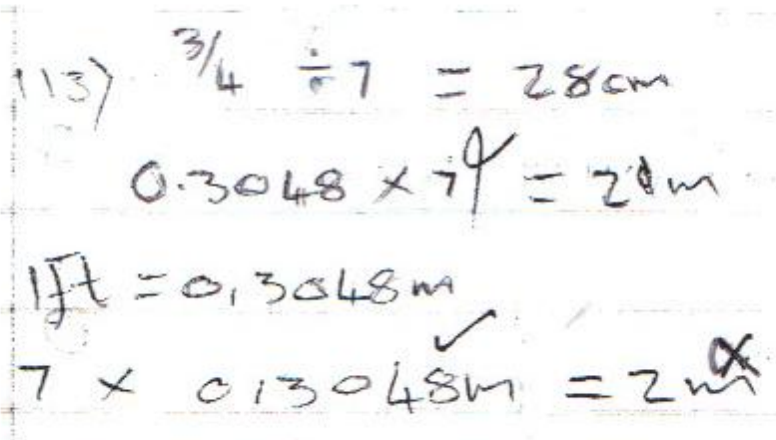
Under this heading, I consider three constraints to learners' success in the tasks. These are: Poor Conceptual Understanding; Misconceptions and Language Related Misinterpretations.

a. ***Poor Conceptual Understanding***

One of the main impediments to the learners' success was a poor conceptual understanding. Many learners struggled with the mathematical concepts involved in the scenario and/or questions. In this category I consider some learners' poor conceptual understanding as revealed in the questions 1.1; 1.2; 3.1; 3.1.3; 3.2.3; 4.1.2; 5.1.3; 5.2 and 5.3.

Q1.1

Participant 2 performed poorly in this question 1.1 which could be seen as a context free question because it did not require any information provided in the scenario. The learner obtained only one mark in this question. When the learner was asked to convert 72 inches to centimetres and given in a table that 1 inch equals 2.54cm, the learner's response was: 72 inches ÷2.54 cm = 3.5cm. The learner did not understand that multiplication by a whole number increases the values and division decreases the value. The next question required the learner to convert the answer found in the previous question to metres. The learner's response was 3.5cm. Clearly, the learner had not understood the question or simply ignored the question by repeating the previous answer. When asked to determine how many centimetres of iron bar was needed if ¾ of a 7ft iron bar was required, the learner's response was:



The learner identified from the table that 1 foot is equal to 0.3048m and hence 7 feet would be 7 x 0.3048 metres, but was unable to reason that ¾ of the result was then required.

Q 1.2

Participant 3 (P3), said that he had seen a socket like the one referred to, but said it was used for a bicycle. For Q1.2.1(a), he said he did not need the diagram to calculate the circumference as the diameter was given, but he erroneously substituted the diameter (1.5cm) for the radius. For Q1.2.1(b), he needed the diagram to determine the height (5cm) in order to calculate the surface area which he correctly identified from the many diagrams given. However, he continued to use the diameter value (1.5cm) for the radius and doubled this value (3cm) when he substituted it into the surface area formula. Clearly, the respondent understood the concept of radius and diameter. The error could be attributed to just a slip.

Q 3.1

This question dealt with ratio based on the number of cows and the amounts two boys, Sipho and Themba earned. Participant 7 (P7) lost marks carelessly through inaccurate calculator input or erroneously transcribed the incorrect amount in 3.1.1.

Participant 3 did not understand the concept of ratio in question 3. When asked in question 3.1.3 whether it was correct that Sipho earned less than Themba, the learner responded:

> *Yes, he was correct because Sipho earns R60 a week and Themba was paid R100 per week. Themba earns R40 more than Sipho.*

Instead of making a comparison using ratios, P3 looked at the values of their wages in isolation from the number of animals each boy was taking care of; hence, subtracting the values, according to the learner, would show the difference in their earnings. Respondent 4 answered the question by explaining in words how Sipho earned more than Themba but also failed to use ratios to support his argument.

Q 3.2.3

Question 3.2.3(a) asked whether using the second bucket would double the amount of milk Sipho takes to the farmer's house per trip. The second part (3.2.3(b)) asked them to prove their answer from 3.2.3(a). Participant 2 drew a bucket that was broader at the top than at the bottom and a cylinder that had straight sides. However the learner said that the shape was the same but only the volume was different.

T: Ok. Are the two diagrams the same? The shape is the same for both?

L: Yah. The shape is the same.

T: Ok. So when they say the bucket is like a cylinder, do you think they are right in saying that?

L: Yah because the… but the only thing that will be different is the volume of both the bucket and cylinder.

Participant 7 did not understand the relationship between doubling the dimensions of the bucket and the effects it would have on the capacity of the bucket in 3.2.3(a). She answered "yes, he can carry more milk" to Q3.2.3(a). Then in the (b)-part she used the volume found on 3.2.2 and then doubled it, getting twice the volume. She then showed the ratio as 2:1.

Respondent 9 managed to double the dimensions of the original bucket and substitute them into the formula but was unable to determine how much larger the volume became.

Q4.1.2

When asked to find the range of baby boys' masses at birth, Participant 8 listed all the values on the y-axis.

Q 5.2

Respondent 1 was unable to convert the interest rate per annum to a corresponding monthly interest rate. However, there was correct substitution and calculation of the formula.

Q 5.3

Respondent 1 did not draw the diagram as required in the question. The calculation was based on the reduction of the area of the picture frame, rather than a reduction of the dimensions. The respondent was aware that the scale needed to be reduced, however.

b. ***Misconceptions***

Under this heading I present example of learners' misconceptions of certain mathematical concepts as revealed in their responses to Questions 5.1.3, 3.2.3 and 5.1.4. The category of misconceptions is different from that of poor conceptual understanding. Here I take Brodie & Berger (2010, p169) view that "a misconception is a conceptual structure, constructed by the learner, which makes sense in relation to her/his current knowledge, but which is not aligned with conventional mathematical knowledge."

Q 5.1.3

This question presented problems to many learners, because it needed a reversal or inverse technique. They needed to calculate the price of the CD player before VAT was added. The solution require a setup of an equation which is mathematically more demanding than the corresponding direct problem which required the calculation of the output when the input is given. Many learners were unable to recognise that this was an inverse problem and not a direct one. In fact, in this question (5.1.3), 97% of the 73 learners attained zero marks. Respondents 1, 6, 9 and 5 calculated the 14% VAT on the final amount and subtracted this from the final amount. Respondent 4 was unable to calculate the original amount before VAT was deducted.

Q 3.2.3

In Q3.2.3 (a) it was asked whether the volume of the bucket would double should the dimensions double and P5 incorrectly answered 'yes'. Upon proving her answer in Question 3.2.3 (b), the respondent 5 (through her own method) achieved a correct ratio of 8:1. Despite this, the respondent failed to go back to her answer in Question 3.2.3 (a) to change it to 'No". The respondent could not see the connection between the ratio 8:1 and "double" as meaning 2:1. For P6, the misconception was that doubling the dimensions of the bucket would also double the volume and hence she concluded that the ratio of the original bucket to the bigger bucket would be 1:2 instead of 1:8.

Q 5.1.4

Respondent 5, on deciding which shop offered the best discount, incorrectly selected Blue Gum:

> *Because I just looked at the percentage off the normal price…They say 19% off the normal price including VAT and Casanova says a quarter of the normal price including VAT so I looked at the percentage and found it. The percentage was larger than any other store.*

Clearly, according to the above response, P5 interpreted a quarter off the normal price as a quarter percentage off the normal price and hence much less than 19%.

c. ***Language related Misinterpretation of Questions***

Another constraint experienced by many learners, was their misinterpretation of many questions because of a misunderstanding of the language used in the tasks. I consider misinterpretations of learners identified in their responses to Questions 4.1.2; 4.2.1; 1.3; 2.2.3; 3.1.2; 3.3 and 5.1.3.

Q 4.1.2

"Range" as a specialist mathematical term refers to the difference between the highest and lowest scores in a set of scores, the difference between the highest and lowest points on a graph or a set of values taken on by a function for elements in its domain. In this question it needed the difference between the highest mass of a baby boy and the lowest possible mass, given the different graphs. Respondent 1 had an idea that the range had something to do with the highest and lowest. She looked for the highest point in the graph where the line intersected and then the lowest point and subtracted the amounts (17 – 2 = 15). However, she did not take into account that the range required was during birth and not at 3 years. Respondent 7 explained in her interview how she misinterpreted the word "range"

T: … What is range?
L: I messed that one.
T: You know what range is?
L: Yes I know but I forgot.
T: How do you find range?
L: From what I wrote here I took the highest number and subtracted by the lowest.
T: So the highest minus the lowest. That's correct. What's the highest number?
L: 13.
T: and the smallest?
L: 2.
T: Where you got that from on the table? Where you read 13 and 2?
L: 13 and 2 [pointing to the highest and lowest values of the graphs].

Q 4.2.1

In this question, many learners misinterpreted the figures representing the mortality rate. They were unable to correctly interpret the meaning of the phrase "mortality rate", which was provided at the beginning of the question. None of the 73 learners used the correct meaning of the figures representing the mortality rate. Some learners (20) interpreted the figures as percentage of deaths and 16 of these arrived at an answer of 16416, while 4 learners stopped at the first of finding 8.8% of 18 000 = 1 584. There were 3 other students who used the same algorithm but used a different percentage. There were 18 learners who considered the figures as actual deaths, and did a subtraction of 18 000 - 8.8, while 2 learners did a subtraction of 18 000 - 22 (sum of all figures in the table). Respondent 4 misinterpreted the values in the table as percentages rather than as number of deaths for every 1 000 live births. Respondent 1 assumed that the values in the table represented percentages:

> *Well, I thought it was referring to the percentages… you know…I was just unsure whether to …like you know for example, in 2004, 2% was of polio and…you know…infant…you know naturally. That's how I looked at it.*

There were 18 learners who incorrectly interpreted the numbers in the table as actual number of infant deaths. Participant 2 explained:

L: 2006 there's 1.8 that died from polio.
T: 1.8 what?
L: Infants.
T: 1.8 infants?
L: Yah.
T: So in 2004 this would say there's 2 infants who died, 1 infant died, 5 infants died and so on?
L: Yah.

Participant 7 was confused about whether it represented a percentage or the actual number.

L: …I think two of the infants born in 2004 had polio. I think 2 died because of polio.
T: So you say two infants died.
L: I'm not sure if it's 2 % or 200 died or 2000.

As discussed in Section 5.3.3 (to come), one of the reasons for the learners' misinterpretation was the placement of the crucial information so far away from the actual sub-question. None of the learners used the explanation of mortality rate given in the first part of Question 4, to answer the question.

Q 1.3

This question involved a scenario about wages and hours worked. The following extract is taken from the examination task:

1.3 John was paid R11.50 per hour. In his last week, he worked 9 hours a day, Monday to Friday. His employer deducted (subtracts) from his gross wages, 1% for sick leave and 1.2% for Unemployment Insurance Fund (UIF).

1.3.1 Workers are allowed to work 40 hours at the normal rate, and above that, is regarded as overtime. They must be paid overtime at a rate of R15.75 per hour. Calculate John's gross wages for the last week he worked.

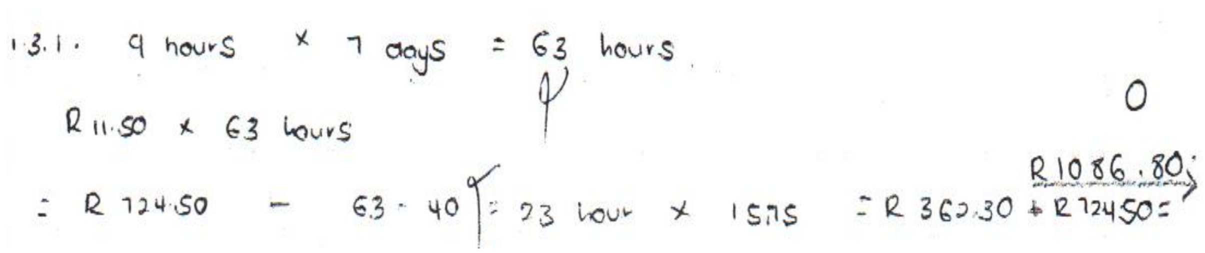
1.3.2 Determine the deduction from John's wages towards his sick leave and UIF in his last week.

1.3.3 John's employer was compelled by the trade union to increase their employees' wages by 10%. The employer agreed to the 10% increase if the workers reduce their working hours by 10%. If John were still employed:

(a) Determine how many hours he would now work?

(b) Is this a good decision? Substantiate your answer.

The words "last week" posed problems to P6 in answering question 1.3.1, where she was asked to calculate John's gross wages for the last week he worked. The task designers' intended interpretation of "last week" was to mean "the previous week". P6's interpretation of "last week" implied "7 days in a week" and she multiplied 9 working hours by 7 days giving 63 working hours. Although P6 understood the concept of overtime as evident in her calculation showing a deduction of 40 hours overtime from the 63 hours obtained, the language misinterpretation of the question posed a constraint to her successfully answering this question.



The word "deduction" posed a problem to the respondent 10 in answering question 1.3.2 where he was asked to determine the deduction from John's wages towards his sick leave and UIF. The learner was supposed to calculate 1% for sick leave and 1.2% for UIF, which he did correctly. He then subtracted these two amounts instead of adding them together to find the total deduction. The learner interpreted the word "deducted" to mean subtract possibly because the scenario included the word "subtracts" within brackets following the word "deduction". While an attempt was made to assist English second language learners by providing the meaning of the word, this step had in fact worked to the detriment of this learner.

L: Over here his sick leave. I calculated the amount of sick leave………but……

T: This was right. You did this right. So this was how much was taken out for sick leave and this was how much was taken out from UIF. Then you took the both and you subtracted it. Why you did that?

L: I sir, maybe I was finding this…the money left. I'm not sure. I can't remember.

T: Okay, what does the word deduction mean?

L: Deduction is like the money deducted from the salary or wages. The money that is taken from the wages.

T: Ok so it's taken out. So that's why you subtracted?

L: Yes.

T: Ok. So you looked at the word deduction and you thought I must subtract.

L: Ja, because I couldn't add. Ja, this word here [deduction] gave me an influence. I couldn't add because of this word.

Q 2.2.3

This read: *The last round robin matches will be Spain against USA, and South Africa against South Korea.* Question 2.2.3 (b) read: *South Africa and USA need a total of 6 points to guarantee their places in the next round. Suggest any score that will enable South Africa to move to the next round, using the soccer fanatic's scoring system*.

Respondent 3's answer was:

If South Africa wins two matches then it will receive 6 points enabling the team to reach the next round. If they win the 3rd match it would be even better.

Clearly the respondent missed the sense of the question. What was required was a *score* and not the *number of matches* to get the points. Two aspects need consideration here: The question had too *much information* and some *distracters*. For example, Question 2.2.3 (b) should not have mentioned anything about USA as no calculation was required for USA. The respondent was unable to distinguish between the crucial information and context information. Secondly, the word '*last*' in question 2.2.3 is ambiguous as it could mean the final match (which was what was intended) or it could mean the previous match, giving the impression that there were still more matches to come. Hence the learner was thinking about SA having to play and win two matches to get the 6 points.

> *To work that out I needed to know…check out how many points…they needed 6 points. They needed to play 2 games that will get them 6 points in order for them to qualify. I looked at this proposal. Points that say that if you win with more than 2 goals…get more than 2 goals you get 3 points plus one you needed at least one win with more than 2 goals and another win. 2 Wins and 2 goals.*

Respondent 8 also interpreted the word "last" as meaning the 'previous' match and hence found possible combinations that would total 6 points.

> *South Africa will need to win 2 matches and draw by 2 in order to guarantee their place in the next round.*

Question 2.2.3(b) which asked, using the fanatics scoring system, what score South Africa needed to guarantee their place in the next round, also posed problems to Participant 10. To guarantee a place, a team needs to have a total of 6 points. The learner clearly knew what crucial information was required to answer this question; however, he was hampered by the word "margin".

T: OK. So, what information you needed to answer that question?

L: Like you know …over here I needed to know for a win how many goals and for a lose, how many goals.

T: So you needed to know by how many goals they're winning and losing by?

L: Yes.

T: And where you looked for that?

L: Over here.

T: Where they gave you that?

L: See over here they say lose by two or more goals. No point. If they lose.

T: Okay.

L: And if it's a win by a margin … I don't know what that means, right…by 2 or more goals e.g. 2-0 or 4-1 [reads from question paper].

Q 3.1.2

Participant 5, in answering question 3.1.2, assumed the task designer was asking the same question as 3.1.1 (i.e. how much will Sipho earn for looking after one animal), and hence added ten animals to the existing 48 animals and proceeded to repeat the calculation done in question 3.1.1 (instead of finding Sipho's total wages for looking after a total of 58 animals). Participant 6 used a strategy where she calculated how much Sipho would earn per animal and how much Themba would earn per animal and drew her conclusion on this information. The respondent was penalized as the question required the comparison as a ratio.

Q3.3

Participant 2 did not realise that the scenario was based on two different accounts at the same bank.

T: If you had to choose one of these accounts, which one would you choose to open?

L: Standard Bank.

T: I think both are Standard Banks, but these are different kinds of accounts. Which type of account would you prefer?

L: (Points to the SUM1)

In response to providing the advantage of the Student Achiever Account, the learner responded: *"…it's free at Standard bank to withdraw."*

Q 5.1.3

The terminology "including VAT" and "excluding VAT" confused P10

L: Ay. I don't know but the first one I calculated and I got 246. Which means I was working out the discount. So…Now if I minus the disc…no the discount is 246 over here, I had to find another discount…you know …that discount?...I don't know how to work it out because it say excluding. I had a problem with that.

T: Okay, you got confused with the words excluding and including vat?

L: Ja, Ja.

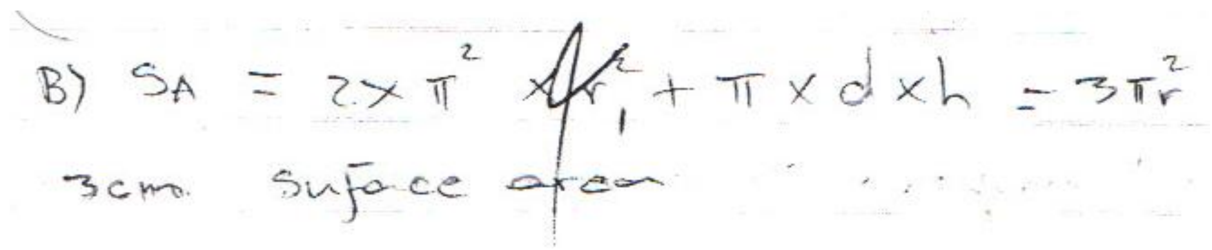
5.2.2 Some strategies utilised by learners when answering the examination questions

The learners utilised various strategies in the different questions, in an attempt to provide answers to the questions. Under this heading I will discuss the following strategies; Number Grabbing; Guessing without checking; Making simplifying assumptions and Extracting information without making sense of the context.

a. *Number grabbing*

This category is linked to category 5.2.1 of poor conceptual understanding, but is intended to provide actual examples of learners' work where numbers are used arbitrarily without much thought given to whether this makes sense or not. Schoenfeld (1998) was the first to coin the term "number grabbing". "Number grabbing" occurs when learners are confronted with problems they do not understand and they then resort to a 'number grab' to enable them to perform calculations and obtain an answer. The phrase captures the essence of P2's approach when calculating the circumference and surface area of the nut. For Q1.2.1(a) he wrote:

For Q1.2.1(b) he wrote:



P2 was unable to make any substitution into any of the given formulas for circumference and surface areas. He had no idea where to look for the values to be substituted into the formula. In the interview, he responded as follows:

T: Ok. Now if you look at the questions here…see here they told you to calculate the circumference. Now if you look at the formula, what you needed in the formula?

L: You needed to get C = 2 x π x r.

T: Yah. So out of all those, what is missing that you needed to find?

L: You need to find the … (long pause).

T: Could you have answered this question without looking at the diagram?

L: No.

T: Is there nothing here [points to question 1.2.1(a) where the diameter was given], that tells you that you can answer this without the diagram?

L: (Pauses) . . . No. there's nothing here...

T: When you look at the diagram then which information you looked at? If you want you can look at your answer sheet…..Which information you took from the diagram to work that out?

L: I just took the information from here [points randomly to the diagrams].

T: Ok. Which value? Is it this, this, this, this? [Points to several values in the diagram]

L: This value [points to 3.5cm].

The respondent had no clue as to what the scenario entailed nor did he understand the questions asked. He simply resorted to grabbing numbers from the question and diagrams to concoct an answer. There are many other examples of his technique, but it would entail discussing the specifics of each question, which would take too long.

Another example of number grabbing is provided by the response of P5 to Q3.1.3, when asked to compare the ratios of Sipho and Themba's income to the livestock. He answered 10:1, and based it on a number presented in Question 3.1.2. This is indicative of the respondent not knowing how to calculate the ratios and hence resorting to a number grabbing technique from the previous question.

Respondent 9 understood what a growth chart was, revealing that he had one at home, but was unable to read off the chart as evidence in his answer script. The respondent was merely taking numbers off the chart as his answers. When asked how he obtained certain figures the respondent responded: "*Erh…sir, I don't know how. I was finding it hard to answer these questions".*

Other examples of P9's responses are 40 + 10% = 50 (Q 1.3.3) and 1,10% ÷R180,00 = R12,79 (3.3.1)

b. *Guessing without checking*

Somewhat related to but a little less arbitrary than, the number grabbing technique is the guessing without checking technique, where learners make a guess but do not check whether the answer is feasible. Here I look at questions 4.2.2; 5.1.4 and 3.3.2.

Q 4.2.2

On the calculation of the probability of infant deaths due to HIV-Aids in 2004, P9 hazarded a guess of 28%.

T: …how did you get 28%?

L: Sir, like I just took the probability of 28%.

T: But why did you choose 28%? Why not 50, 30 or 20%?

L: No sir, I don't think it's so much people.

T: So you took it from your own experience?

L: Ja, from my own experience.

T: So you didn't look at the table, the number and all that?

L: No I did not.

Q5.1.4

Participant 7, in determining which store to buy the CD from in Question 5.1.4, based her answer on anything but calculations.

Casanova because they offer higher discounts.

P7 did not justify her answer with calculations. In determining the cheapest store of the three, P8 said Doggy Sound. She based her answer on whether the shop included or excluded VAT. Doggy Sound was the only store to exclude VAT. The learner did not compare the stores by doing the calculations to determine the cheapest store.

T: Why do you say that's the cheapest?
L: Because it does not include VAT.
T: You think it is cheaper than this one here where they give 19% discount?
L: I think this one is cheaper.
T: You think the Doggy Sounds is cheaper?
L: Yes.
T: Did you do the calculation?
L: No.
T: Then how did you come to that conclusion?
L: Sir, it says excluding VAT.
T: Oh. So you say excluding VAT should be cheaper?
L: Yes.

Q 3.3.2

This question asked for two advantages of the Student Achiever Account based on the information on the table. The learner provided a general explanation:

It got less charges than sum and far more cheaper to use it.

The learner did not make a systematic comparison of the information given in the table, such as the student achiever account does not require a minimum balance whilst the sum account requires a minimum balance of R20.

c. *Assumptions made by learners*

Often learners made assumptions that simplified the questions, thus helping them to arrive at some answers. Below are two assumptions that were evident in the examination responses.

Participant 2 felt the scenario in question 3 to be “confusing”. The learner made his own interpretations of the scenario. For example, he assumed that the boy, Sipho, who was earning less, was younger. He also assumed that the number of animals looked after is related to time. Hence, the “elder” boy, Themba, looked after animals for longer.

T: Ok, what was confusing about it?

L: How much does Sipho earn and how much does … what’s this guy’s name… Themba, earn. From comparing both…how much they get, and like Themba used to get extra because he was older and he wants to look after the cows for longer. And Sipho, he used to get less money because he looked after the cows for a shorter period of time, and he was younger.

T: Ok. He was younger?

L: Yah, I think so.

T: Did they say anything about him being younger?

L: Yah, they say it somewhere (looks at question paper and reads silently).

For Question 3.3.1, P2 assumed that Themba was withdrawing from an ATM. This assumption was based on the learner’s own experience of withdrawing money from his account using an ATM rather than an over the bank counter. This led the learner to believe the charge to be R3.65. With a fair amount of information on the given table, the learner zoomed in on key words he was thinking about. Hence, he zoomed in on the word ‘ATM’ believing that the withdrawal takes place through the ATM. The learner blocked out all other information from the table and hence overlooked the fact that the row he chose to obtain the value of R3.65 was actually the penalty for withdrawing more money than was available in the account.

d. Scanning the scenario to extract crucial information

The analysis revealed that the learners often scan the context information, with the purpose of picking out crucial information but that their priority is not to make sense of the context. This was evident from the responses of P2, P4, P6 and P7, with respect to the calculation of the volume of a bucket, given the formula for volume of a cylinder. After drawing a bucket and a cylinder, P4 said that the shape of the cylinder and bucket was not the same:

> *…the cylinder and the bucket is not the same because the bucket has a bigger circle at the top than the circle at the bottom and the cylinder got equal circles.*

The respondent, however, worked out the volume of the bucket using the formula for the cylinder despite knowing that the bucket and cylinder are not the same shape. When asked whether he was imagining a bucket when answering this question, the respondent said:

> *No. They gave us this cylinder.*

This shows that he merely substituted the values into the formula and worked out the answer, without trying to figure out whether the formula was appropriate to the context or not.

Participant 7, upon being asked to imagine and sketch a bucket and then a cylinder, also drew a bucket where the diameter was broader at the top than at the bottom which does not make it a cylinder, and hence the given formula for the bucket would be incorrect. The learner noticed this difference as reflected in the following transcript:

T: …Do you think the bucket and cylinder looks the same shape?
L: No.
T: … Now when you were doing this question did you imagine the bucket?
L: Yes.

P7 admitted that he did not think that the same formula could be used for both; however, he said he "*just used the formula*" because although he imagined the bucket, he "didn't *really concentrate".*

P6 too, indicated in her drawing that a bucket was not the same as a cylinder in that "*The bucket is much more wider, the cylinder is straight with two circles".* The respondent also knows that the formula given for a cylinder would not apply to the bucket she is imagining. However, she did not imagine the bucket when answering this question. Instead, she just "*took the measurements of the cylinder and put it in the formula".* This shows that P6 did not try to judge whether the formula was appropriate or not, she just detached herself from the scenario and answered the question as if it was context free, using only the given formula.

P2 thought that the shape of the bucket and cylinder was the same even though he drew a bucket that was broader at the top than at the bottom compared to his cylinder that had straight sides. He said that the shape was the same but the volume was different.

T: *Ok. Are the two diagrams the same? The shape is the same for both?*
L: *Yah. The shape is the same.*
T: *Ok. So when they say the bucket is like a cylinder, do you think they are right in saying that?*
L: *Yah, because the… but the only thing that will be different is the volume of both the bucket and cylinder.*

These responses indicate that the learners did not trouble themselves with the minor information that the shape of a bucket they drew was different from that of a cylinder, and used the formula given.

5.3 LEARNERS' PERCEPTIONS AND EXPERIENCES OF THE CONTEXTS

For many learners, making decisions about the questions posed in the task may not necessarily be on the same level as making decisions about an everyday experience. In a real life situation, decisions are based on extraneous factors which may be very different from what the examiner considers. Some learners may use their knowledge about the context to gain a better understanding of the scenario presented in the examination paper. Other students may get distracted by the context if the information in the examination paper differs from their own personal experience of their context. Under this category, I look at the learners' perceptions of the various contexts that were used and where possible, the ways in which their experience impacted on their interpretation of the examination task.

5.3.1 Relevance of Context

In this category I consider the learners' perceptions of the relevance or interest of the context. Some learners had an interest in the scenario, some liked certain contexts some of their parents had an interest in it, or they themselves practised, or the scenario was within their experience.

In terms of the various contexts, some learners found certain contexts relevant while others perceived them to be irrelevant. With respect to the context of the socket (Q1.2), some learners (P4, P5 and P9) said that they had seen a tool like that previously and found the context relevant. Others (P2, P3, P6 and P7) did not think it would be relevant to them. In fact, P2 misinterpreted the diagram of a socket, and related it to his experience of a waste bin which he noticed at shopping malls:

T …Have you seen a socket before? In real life?
L: A round one like that?
T: Yah. They say it's round – it's got a square hole on the top and underneath it's got a round hole. Have you seen something like that?
L: I've seen something like this. But it's made of concrete and steel.
T: Ok. What is it used for?
L: It has this … ur… it has a steel bin inside here and this is the concrete barrier around…it has a decoration around the concrete barrier, and …Yah…they had a steel bin that picks up from inside here – picks up and empties into a truck.
T: Ok. Oh you're talking about the waste bins in the street?
L: Yah, Yah, I've seen it in the mall, actually.
T: Ok. So that's what you imagined?

P2's interpretation of the diagram as being a bin is far from what the task designer must have expected. Cooper (1998) also notes in his research that "some children's accounts of their answers were a tendency to refer not to the given data but to their own experience…" (p. 29).

Most learners were positive about the World cup scenario of Q2, as expressed by P3:

> *This one is more relevant because its sports and everybody engages in sports somewhere in life so this story is something they can relate to and it's easy. I think I scored marks here.*

However, there were some learners (P4, P6 and P7) who did not consider it to be relevant. Similarly for the other contexts (wages, growth chart; mortality rates; looking after animals), there were some learners who said that the context was relevant and others who did not agree. Some learners commented that certain contexts were relevant only to adults. P1 felt that the context of calculation of salaries (Q1.3) would be relevant to her in the future when she enters the working sector. P2 felt that the scenario of Q3.3 would only be relevant to those people who are working and not to him. He also felt that the scenario of Q1.3 would be useful to "working class" people since it dealt with wages, UIF and sick leave and was not useful to school children:

T: … Do you think this scenario that they gave you… the story is useful to us in our daily life?

L: Ur… to the working class it is useful but not to the schooling children.

T: So to you it wasn't really useful?

L: Yah.

T: But maybe later on it would?

L: It would.

The above comments are useful for ML teachers and task designers to consider, as Murray (2003) stated that, the problem is that learner's experience 'real life' very differently from adults and the 'so-called' real life contexts are not necessarily accessible to all learners. As Prestage & Perks (2001: p.107) argue, often contextual problems set in 'real' contexts, are "hardly relevant to anyone other than the question setter".

5.3.2 Reasons offered for the relevance of contexts

When the learners were probed about why they found certain contexts relevant or helpful, some learners did offer some thought-provoking reasons; however, most learners offered arbitrary or random reasons. For example, P3 said he liked the scenario of looking after animals (Q3) because it concerned working and making money; and for the CD player context (Q5), P4 explained that *"the price is given to us. How much the CD cost so you can decide where to buy it".* P10 explained:

Because we need to know what's a discount? What is VAT? What is the normal price? Ja, it is very important because sometimes they just write including VAT …we have to know how to calculate the VAT…what is the discount. They say discounted …you must know what it is.

P1 then said: *VAT is something we should know as well as it refers to…you know…other subjects that I do e.g. accounting, so yep…relevant*.

P4 preferred the socket question to the soccer scenario as he felt the socket would be more useful than soccer. In contrast, P6, despite having no interest in soccer, explained why she preferred the World Cup context (Q2) over the socket context (Q1.2):

> *…it's much easier to understand the points are given, you don't need to use volume, area to get a certain answer, everything is given, all you have to do is look at it and calculate the number of points.*

This indicates that her preference was based on the fact that she preferred algebra over shape and space.

There were some learners who provided compelling reasons for the relevance of certain contexts e.g. the growth chart (Q4). Although P6 had not seen a chart like this, she was aware that it measures children's weight as they are growing and can be useful in determining how well a child is growing.

P7 found the growth chart scenario relevant and important as she had a baby of her own. The given growth chart was not unfamiliar to her. P8, too, is a single mother and admited seeing a growth chart like the one in the question paper. The learner knew that such a chart was helpful to monitor the growth of her baby. However, she did not understand all the details on the chart.

5.3.3 Non- recognition of crucial information

It was found that many learners missed crucial information provided in the scenario, which meant that they could not answer the question correctly. I use Q2.2, Q4.2.1 and Q2.1 to supply examples belonging to this category.

Q 2.2

P4, in answering Q2.2.2, did not consider the crucial information necessary to answer this question. He did not see that the number of goals scored by each team was given in the scenario and made a judgment using personal experience*:*

T: In order to know if they scored more than two whether they drew less than two, or what. Where would you find that information?

L: In the scenario.

T: Point it out for me where it shows you this.

L: Here [points to scoring].

T: But that show the points but where does it show the goals.

L: Shows the goals?

T: Yes, how many goals South Africa got and how many goals maybe USA got if they played them.

L: They didn't give us the goals.

T: You didn't look at this part here? Isn't here they gave us the goals?

L: Yes.

T: So you answered that question you didn't look at this part here?

L: No.

Q4.2.1

This question required learners to calculate the number of babies who survived their first birthday. The scenario, presented at the beginning of Q4, contained the crucial information that would allow them to interpret a mortality rate of 8,8 as 8,8 deaths per 1000 births. The scenario appeared in the beginning of Q4. There were then 7 sub–questions which followed, none of which required any crucial information provided in the scenario. Then Q4.2.1 appeared as the eighth sub question, and the only one which needed that the crucial information. In Q4.2.1, most learners knew the procedure needed, but the problem was with the interpretation of the figures in the table. None of the 73 learners could appropriate and apply that crucial information in their solution.

Respondent 1 did not know what the values in the table represented. When asked what could have been done to avoid this, the respondent replied:

> *I'd put this information here [points to below the question] so it would be in the face or probably highlight it or make it bold or something… you know.*

R2 said she missed the crucial information because she *"didn't read the block"*; when directed to the part where the information was given, R4 said that it would have been better if the information was given close to the question so it could be seen. When directed to the scenario at the beginning, Respondent 5 then realised that the values represented deaths per every 1000 live births and suggested that:

> *They should have put the scenario just above the question so we wouldn't have missed it out. They put the scenario above the different set of questions on the scenario and put another table they could have put it under each and said refer to A or B that would have been better.*

R6 said that that mistake could be avoided by the task designer by

> *Putting the relevant information where it's needed the most, instead of putting it in a paragraph at the beginning.*

All the other participants who were interviewed explained similarly that they missed the crucial information because it was so far away from the sub-question.

Q2.1

Participants 1 and 2 felt that the information provided in the scenario was not necessary to fill in the table of Q2.1.1 and did not use the information for Q2.1.5 where it was necessary.

P1 did not think the scenario was necessary to complete the values in Table 2: it could be done by following the number pattern: "*…it would have been possible to work without this given* [the scenario] *as they gave you this first two"* [values in the table]. The respondent felt that if the second value in the second row was also given, she could have worked out the other values in the second row: "*So I felt if this was given as well* [second value in second row], *I could have worked all that out* [the rest of the values in the second row]". She tried to use a strategy of sequential number patterns rather than finding a relationship between the variables. The respondent was not looking at the relationship between the number of workers and the months taken to complete the stadium but merely a pattern in the independent variable, the number of workers. Because she did not refer to the information in the scenario which specified that the building needed to be completed within 6 months, her answer for Q2.1.5 did not take this fact into account. She just said: *"Yes, more workers, less time"*.

P2 also felt that the scenario was not necessary in completing the table of values showing the relationship between the number of workers needed to complete the stadium and the time it would take to do so. When asked how he could have found the answers to the table without referring to the scenario, he explained:

> *L:* *By reading the questions and seeing what is required … see they say calculate the numeral values of A, B and C. You can see A they needed 400 workers…they got number of months – 2 months, right? See, so you follow these calculations here and I'm sure you'll find the answers to B and C.*
>
> *T:* *So you're saying that you didn't need this story here; we could have still worked it out…*
>
> *L:* *Yah, yah. We could have still worked it out.*

The learners' lack of understanding of the scenario is further revealed when asked in Question 2.1.5 whether it would be wise for the contractor to save money by employing only 120 workers. The learner's response was "*Yes. Because the stadium will be completed on time and labour costs will not increase unless workers are given overtime"*. This response shows that the learner was focusing on the money issue rather than the time issue, which was emphasised in the scenario. The learner was not able to relate the question as a sub-question to Question 2.1 which is related to the relationship between number of workers and time to complete the stadium and not wages. The given scenario has not helped the learner to see this relationship. A possible reason for not using the crucial information to answer Q2.1.5 was that it was possible to answer all the preceding four questions without using that information; however, it was crucial for Q 2.1.5. But in a similar manner to Q4.2.1, they may have missed it because the crucial information was only needed five questions after it appeared.

5.3.4 Personal experience of the context

Often the learners' own experience of the context influenced the ways in which they interpreted the questions. In this category, I look at the learners' experiences of certain contexts, offering examples arising from Q3.2, Q3.3, Q1.2 and Q2.2.

Q3.2

In Q 3.2.3(a), P10 was asked whether Sipho could double the amount of milk he could carry if he used a bucket whose dimensions were double that of the original bucket. The intention of this question appeared to be to test the learner's ability to determine how many times the volume of a 3-D cylinder increases if its dimensions are doubled. P10 responded to this question: "*No. Heavy*", implying that by doubling the dimensions of the bucket, Sipho will not be able to carry the full bucket of milk, because it would be too heavy for him to carry. Thus he would not be able to carry it and therefore would not be able to double the amount he could carry. This was a personal judgment based on a consideration he would make in a real life experience. The learner was able to calculate the correct volume of the bucket with its dimensions doubled in Q 3.2.3(b). My opinion is that Q 3.2.3(b) should have preceded question 3.2.3(a) so that the learner would have first calculated the volume of the bucket with its dimensions doubled and then perhaps could have drawn a conclusion about whether Sipho would have doubled the quantity of milk carried. Perhaps the learner would have then responded: No. It would be too heavy as the quantity of milk is now 8 times more than before.

Q3.3

Participant 8's own experience with having a Student Achiever Account influenced her in answering Question 3.3.1, which asked how much Themba would pay for withdrawing a cash amount of R180.00 from his account. The learner did not study the table carefully, but merely saw a figure R0.00 under Student Achiever and concluded that Themba would pay R0.00 for withdrawal. The learner was perhaps confident that the response was correct as she herself has an achiever account and knows that she does not pay bank charges. This fact is further elucidated in her response to 3.3.3, asking for the advantage of a Student Achiever Account: "*The student achiever account does not charge bank charges when withdrawing."* However, according to the given data, this was not true. The learner disregarded the information provided in the scenario and used her own experience.

Q1.2

P2 had entirely misinterpreted the diagram of a socket, and related it to his experience of a waste bin which he noticed at shopping malls. He interpreted the square hole as a concrete structure and the round hole as a steel bin inside this concrete structure. He further described the concrete structure as having decorations around it and the removable steel bin as something that can be picked up and emptied into a truck.

Q2.2

The role of the learners' experiential knowledge in answering Q2.2.3 was reflected in many learners' responses. In Question 2.2.3(a), the examiner wanted to know, using the FIFA scoring format, whether South Korea could overtake Spain with each team having only one more match to play. This question is related to real life predictions in sports, where, for example in a F1 championship, what are the chances of a driver leading the championship by 8 points to win the championship with only one race to go? There are numerous possibilities: the driver has to win the race to secure 10 points and hence win the championship, or the driver can complete the race without being placed provided that the second driver on the log table does not complete the race or is unplaced, or the leading driver can be the runner-up securing 8 points and the second drive on the log being awarded 10 points for a win. This would result in a tie for the championship. Similarly, the learners had to take several possibilities into account in order to answer this question.

The worst scenario was that Spain lost to USA and South Korea won against South Africa. This would give South Korea an additional 3 points bringing their total to 4 points. Spain, in contrast, not get any points and hence would retain its original 4 points. This would mean that Spain and South Korea would end up in a draw.

P4, when asked whether he thought South Korea would overtake Spain with only one match remaining to play, wrote: *"No, because Spain has more points and is a leading team"* The respondent based his argument on what he knew about Spain and replied that Spain was already leading and would not be overtaken. In his interview, he confirmed that he answered the question without looking at the crucial information about the goals scored by each team.

Another learner (P7) provided a judgmental response rather than calculating the various possibilities. Her judgment was based on her experience (whether personal or vicarious) about the quality of the two teams, with Spain being a “better” team than South Korea and hence more likely to win. She said: “*No, because [Spain] is a good team that doesn’t have even 1 lose and South Korea is weak team that doesn’t have a win”.*

The interview with the learner clarifies that her answer was based on judgment rather than an analysis of the scenario.

L: Because they say South Korea is a weak team than Spain. I don’t think they can overtake Spain because Spain looks like they performed more well than Korea.

T: Okay, you based your answer on the way the teams performed?

L: Yes.

T: You felt South Korea is a weaker team than Spain?

L: Yes.

T: That’s why they won’t overtake Spain?

L: Yes.

P8 also answered question 2.2.3(a) by using her judgment about the performance of the team and not on the information provided in the scenario.

L: Sir, because if you take a look at South Korea they lost. They lost one, drew one. They didn’t win while Spain has won and got 4 points and lost nothing and one draw.

T: So you saying if South Korea plays again in that one more match they got to play, you saying they won’t win?

L: Yes.

T: And you saying Spain will win?

L: Yes.

P10 based his argument on the current points each team had as well as the fact that S. Korea had never won a match while Spain had never lost a match. In his analysis, the learner looked at Spain’s current score of 4 points and S. Korea’s current score of 1 point. In his mind, the learner was not considering a possible win by S. Korea (maybe because he views S. Korea to be a weaker team to Spain), and a possible loss by Spain that would result in the teams being tied at 4 points each. The learner was influenced by the team's performance in the other matches and hence never considered S. Korea to win. The learner's response to this question was influenced by his judgment of the team's performance rather than the facts presented in the scenario.

T: Ja, so do you think South Korea can overtake Spain?

L: No

T: Why you think so?

L: See here, if you take a look over here…the win. South Korea has no win, Spain has no loss. South Korea has a loss. Spain has one draw and 4 points.

T: So you just looked at 4 and 1?

L: Yes.

T: And you decided no, South Korea cannot overtake Spain?

L: Yes.

T: But both of them still got one match to play. What if Spain plays a match and they lose? How many points they get?

L: Same thing can happen to Korea.

T: Ja, but what if South Korea wins?

L: If Korea wins they will be equal because they got one point at the moment. But they'll be equal. Still no.

T: But they still won't overtake them?

L: Ja. They will be equal.

T: OK. Did you realise they will be equal?

L: No I didn't realise it but I just realised it now.

T: So when you answered the question you just looked at the 4 and the 1?

L: Ja, I never realised that if Korea wins, it can therefore be …I never realise that.

However P10's experience was useful when working out some questions from 2.2. The learner felt it was important for people to know how scoring is done so that people can enjoy the game.

> *Yes it's relevant to us because if you're a soccer fan you have to know this. Even if you're not going to the stadium…watching the soccer on TV, you still have to know all this in order to enjoy it. You won't enjoy it if you don't know nothing.*

The learner is himself a keen soccer player and is aware of the scoring system. His experience and enthusiasm was fundamental in him performing well in this question. The learner was able to take the crucial information that was necessary in answering Q2.2.1 and Q2.2.2.

T: Ja, okay see here they ask you to complete the points here, right? What information you needed to know in order for you to complete that?

L: You had to know in a country, how many loses the country had, how many wins, how many draws in order to find the points here.

T: Right, so you looked at the table?

L: Yes.

T: And then? How you got the points? Where you looked?

L: Erh…the key. It was like a key.

5.3.5 Complexity of contexts

The complexity of the context in terms of the amount of information given, the language used and distracters, made it harder for learners to understand the scenario and tackle the questions based on it. I look at examples from Q1.2.2, Q1.3, Q3.3, Q2.2 and Q2.2.3(b).

Q1.2.2

When asked for the number of 500ml tins of paint required to paint 1200 nuts, in Q1.2.2, P8 multiplied 25ml (paint required for one nut) by 500ml tins. This question clearly required a proper understanding of the scenario before the appropriate calculation could be chosen. The learner had not understood the scenario. The learner was still thinking in a rote manner. For example, when multiplication was taught in the lower grades, problems similar to the following are used: There are 12 nuts in a box, how many nuts are there in 20 boxes? The learner learnt that you simply take 12 and multiply it by 20 to get the result. Similarly the learner was attempting to make a complex scenario simpler and hence read those parts that may be useful for her to produce an answer. The learner read the following scenario like this: "To paint one nut, you need 25ml of grey paint. How many 500ml tins of paint will be needed…?" and stopped here. Up to here it was meaningful to her and familiar to "other" multiplication problems she had done before. The learner thus simply multiplied 25 by 500 to get 12 500 nuts. The answer was in "nuts" rather than "tins" because the sentence ended with: "…to paint (the 1200 was ignored) - nuts?" When asked why she calculated it as such, the learner responded:

> *Sir, I thought 25 nuts multiplied by 500 will get the answer. Sir I thought if you take 25 tins of grey paint and times by 500 it will give me the answer.*

R2 also misinterpreted this question and thought that one 500ml tin would paint one nut:

> T: Oh, so you saying one tin will paint one nut?
> L: Yes.
> T: That's what you thought?
> L: Yes, that's how I understand.

Q1.3

Question 1.3 on wages and hours worked had lots of information in it which led to P9 eventually giving up trying to do the calculations. At first he started well by calculating that John worked for 45 hours. However, at this stage, he did not separate the overtime hours (5 hours) from the normal working hours (40 hours), but simply multiplied the entire 45 hours with the rate given for overtime (R15.75), totally ignoring the rate given for normal time (R11.50). Furthermore, when deducting UIF and sick leave from his wages, the respondent simply added these rates (1% + 1.2% = 1.3% [also incorrectly added]). He then proceeded to subtract this percentage from the total wages, where he incorrectly attempted to subtract a percentage from an amount [R708.75 – 1.3% = R707.45].

With much probing in the interview, the respondent eventually realised that "*I should take …urh…R11.50 multiplied by 40 then I should get my answer and the other 5 hours was overtime".* When asked why he did not do this in the exam, the respondent said, " *Aye, sir. I wasn't thinking".* The respondent's lack of interest in the whole question is also evident when he simply added the 10% increase to 40 hours and got 50 hours a week.

P4 could not internalise all the information given in the scenario to be able to answer question 1.3. Hence he multiplied the entire 45 hours by the normal rate. He did not break the hours into normal and overtime and work each one separately with its own rate.

In Question 1.3.3 (a), the respondent estimated a 10% decrease in 9 hours per day to be 8 hours which he used to calculate John's new working hours. The estimation was off by 0.1 hours per day.

Q3.3.2

Q3.3.2 required P7 to consider multiple factors: current amount; amount after deposit, less the cash deposit fee which needed to be calculated. The learner was able to do the first two processes i.e. add the deposit to the current amount. In the third process, the learner deducted a cash deposit fee calculated on the total amount in the bank rather than only on the value of the deposit. Multiple steps posed problems to the learner.

Q2.2

With regard to the scoring system used, P2 was not familiar with the way the scoring was done.

T: Ok. Do you know how the scoring is done?
L: Yah. They have penalty shootouts.
T: Ok. And points, how do they get points? Do you know?
L: I'm not sure how they get points.

This question required a simultaneous consideration of large amounts of information. The learner in question, who often scored at the bottom end of the class, was unable to process so many combinations of information at the same time. Hence, when completing the points system in the table, the learner did not take into account the results of the matches in order to calculate the points for each team.

T: So now, here they ask you to complete this point system here. Ok. What information you needed in order to complete the table?
L: You needed to know how many points South Africa scored.
T: Ok. Er…where'd you get that information from?
L: See here. America, right, scored zero, zero then they scored 2 … these points were 2. South Africa scored zero, zero, the draw was 2 and so they have 2 as well.
T: Ok. You're saying they would be same as USA?

L: Yah.

T: OK. So that's how you followed that?

L: Yah.

Upon analysis of the transcript, it became clear that the learner was looking for a pattern in the table as to how the points were derived. It appeared that the learner engaged in a process of summing the values in the column for the win, loss and draw. Beginning with the USA, the learner read the 2 as 2 points and hence summed the zero for a win, the zero for a lose and the 2 for the draw, which gave him a total of 2 points. Using this pattern, the learner therefore resorted to summing the columns for South Africa, arriving at 2 points. The pattern the learner found in the preceding stages then changed when calculating the points for South Korea. It appears that the learner was not so confident in the way he performed his calculation and hence decided to try another technique.

T: What was the last one there… for South Korea?

L: I put down one.

T: How you got one?

L: Because they had one loss, you see? They lost one match and they drew with only one match.

T: Ok. So you didn't make use of the points they gave you here?

L: I looked at one point. Where they get one point if they win.

T: Do they get one point when they win?

L: (Pauses)

T: How many points do they get when they win?

L: Three points. So they only get one point here and they lost one match. So it is like one minus one.

The transcript reveals that the learner was unable to justify the technique used. The complexity of rallying between the fanatics scoring system and the FIFA scoring system in Questions 2.2.1 and 2.2.2, and again in Questions 2.2.3(a) and 2.2.3(b), was demonstrated when the learner used the answers he obtained for the FIFA method of scoring to interchangeably answer questions based on the fanatics system of scoring. The complexity of the scenario had a negative effect on the learner's ability to correctly answer the questions.

The analysis of multiple sets of data had also got the better of P7. Despite her limited knowledge about soccer, P7 used the crucial information given in the scenario (the results of the matches or the log table) to calculate the points for South Africa (D) and South Korea (E). However, when asked to re-calculate D and E using the fanatics scoring system, the learner was unable to take into account multiple sets of data. To calculate D and E using the fanatics scoring system, the learner needed to refer to both the log table to determine how many wins, losses and/or draws and then to refer to the results table to determine by what margin the teams had won, lost or drawn and finally, to take into account how points were awarded by the fanatics.

Q2.2.3(b)

In Question 2.2.3(b), the examiner wanted the candidate to suggest a score that would enable South Africa to go into the next round. South Africa required 6 points to secure its place in the second round. Here, the candidate had to first determine how many more points South Africa needed based on the fanatics scoring system in order to qualify them for the next round. This would be based on the value of D to Question 2.2.2 (b). If the candidate was unable to calculate the missing value D from the table, then it is unlikely he/she would be able to answer this question correctly. The missing value D was calculated as 3 points. This would mean that South Africa needed 3 more points to secure a place in the second round. According to the fanatics scoring system, all South Africa needed was a win irrespective of the winning margin. That means South Africa had to beat South Korea by 1-0 or 2-0 or 2-1.

Participant 7's response for D in Question 2.2.2(b) was 2 points (incorrect – and hence penalized). However the learner used this incorrect answer to determine that 4 more points were required by South Africa to secure a place in the second round. According to the fanatics scoring system, South Africa would have to win by a margin of 2 or more goals to get the 4 points (3 + 1 bonus). The possible score could be 2-0, 3-1, 4-1, etc. The learner, although able to justify that South Africa needed to "win their game by a margin of 2 or more goals to get 4 points", failed to give the actual score which was what the questions asked. I suppose that in the process of considering so many variables – the value of D from the previous question, an analysis of the minimum points required to advance to the next round, the fanatics scoring system, consideration of how many points South Africa already has, the goals needed to achieve the additional score, and finally suggest a score out of a possible variety of scores - the learner lost focus of what the question actually required.

5.4 CHAPTER SUMMARY

In this chapter, I described how the design of the examination task, the strategies used by learners in responding to the examination task and learners' perception and experiences of the contexts, influenced their responses to the examination task. The complex diagram of the socket, errors in the examination paper, the ambiguity in the questions and of certain words, the lack of clarity of the source document, constrained some learners' success. When learners did not understand the problem, they resorted to a number grabbing technique, making assumptions and using their own experiences of the scenario to respond to the questions.

CHAPTER 6

ANSWERS TO RESEARCH QUESTIONS, DISCUSSION AND CONCLUSION

Chapter Four was devoted to a document analysis of the examination question paper and a quantitative analysis of learners' marks per question. In Chapter Five I did a qualitative analysis of the data obtained from learners' written responses to the examination task and interviews with learners. This chapter is now devoted to providing answers to the research questions, to make connections between the findings in this study and existing literature, and to offer concluding remarks.

6.1 ANSWERS TO RESEARCH QUESTION 1: WHAT ARE THE DIFFERENT TYPES OF CONTEXTS USED IN THE GRADE 12 MATHEMATICAL LITERACY TRIAL EXAMINATIONS AND HOW DID LEARNERS PERFORM IN THE DIFFERENT CONTEXTS?

Document analysis of the examination task was conducted in Chapter Four and questions were grouped according to the types of context identified by du Feu (2001). Questions were grouped according to the following types of contexts: context free, real, cleaned, parable, and contrived.

Over half of the examination paper consisted of contexts of the cleaned and contrived type with 45.3% and 50.4% of learners respectively unable to score any marks in these questions. The poor performance in these types of questions was highlighted by Cooper (1998) when he said that pencil and paper test involving contrived tasks compromised 'good practice' as some items disadvantaged pupils who told seriously the injunction to relate mathematics to the 'real world'. Only 12% of the questions in the examination paper were of the real type where learners performed worst: 56.9% of learners failed to score any marks in these questions based on real life scenarios. The best performance was in the context-free type with 48.9% of learners scoring full marks. It is likely that the task designer chose to set questions based on unrealistic contexts rather than questions that are free of context in order to satisfy the claims of Mathematical Literacy. Identifying contexts around which Mathematical Literacy tasks could be designed is challenging, as du Feu (2001, p.3) notes: "Many contexts are contrived because the mathematics used...does not have a ready application in everyday life at a level which children can understand". Thus du Feu (2001) advocates the use of real context although he admits that these are difficult to develop in an examination, which leads task designers to use contrived contexts. He however warns against the use of contrived contexts arguing that the cost to mathematics is enormous, creating an impression in learners that the mathematics is not real.

However, learners have their own opinions about the value of real life contexts. The real life scenario identified in this question paper was the growth chart in Question 4.1. Learners expressed opinions that this type of real life scenario was more applicable to adults, particularly parents, and not within the experiences of school children. It is true that learners' experience 'real life' very differently from adults and the 'so-called' real-life contexts are not necessarily accessible to all learners (Murray, 2003). As one learner (P1) aptly commented when asked about the relevance of the birth chart: "*...currently, to me no, but I think when we have kids or something, for future reference I'd say yes*". Boaler (1993) advised that it was important to avoid unfamiliar contexts, especially contexts that use 'adult metaphors' such as wage slips and birth charts. Perhaps by using such contexts in the narrow setting of an examination devalues the potential impact that engagement with such contexts could have on young adults. It is undeniably a valuable opportunity for learners to engage with issues around what the growth chart is, and how it is used. But perhaps a written examination is not the ideal place to encounter it for the first time, where their dominant concern is to pass the examination, and understanding the value of such contexts is not a concern at all.

6.2 ANSWERS TO RESEARCH QUESTION 2: HOW DID LEARNERS' PERCEPTIONS AND EXPERIENCES OF THE CONTEXTS INFLUENCE THEIR RESPONSES?

The manner in which learners perceived and experienced the contexts influenced the way they responded to the examination tasks. The findings showed that some learners found some contexts relevant while others found the same contexts irrelevant. The context of the socket in Question 1.2 was relevant to P4, P5 and P9, while P2, P3, P6 and P7 did not find the scenario of the socket relevant. There was not much difference in the performance of learners who viewed the socket scenario as relevant or irrelevant; however, one cannot draw conclusions in terms of relevance as two out of the three questions could have been answered without referring to the context. In the case of learners who completely misinterpreted the context, as in the case of Participant 2 who mistook the socket to be a waste bin, his performance was negatively affected. Cooper (1998) also notes in his research that "some children's accounts of their answers were a tendency to refer not to the given data but to their own experience…" (p 29). Many learners found the context of the soccer world cup relevant but again in terms of performance, there was not much difference between those learners who found the context relevant and those who did not. The reasons given for relevance were mostly arbitrary or random, such as it is important to learn about the context because "we need to know how to calculate VAT, discount…", "it helps us in other subjects", or because the learner did not like contexts rooted in shape and space. However, good reasons were given for the relevancy of the growth chart. Most learners were able to comment about the importance or relevance of a growth chart to monitor babies' growth and identify irregularity in growth, but were unable to interpret the chart. While learners may have heard about growth charts, they did not view them as relevant to them as scholars and hence they did not pay attention to how they were read. This partly explains the poor performance in this question. Here again, we see 'adult metaphors' having negative effects on performance (Boaler, 1993). A task designer may assume that tasks set in real life contexts and which are close to learners' experience may interest most learners, which may explain why contexts such as CD players, health charts and the World Cup could have been chosen. On the contrary, Sjoberg's (2000) international study revealed that many learners indicated that they were not interested in knowing more about how cars worked making such assumptions simplistic and unwarranted. The learners' interview responses from this study support Sjoberg's findings because they gave trivial reasons for finding the contexts relevant. Those learners who mentioned the importance of the health chart to them as mothers, were unable to answer the assessment questions very well, showing that their understanding of or familiarity with the chart did not help them answer the questions.

6.3 ANSWERS TO RESEARCH QUESTION 3: WHAT ARE SOME STRATEGIES UTILISED BY LEARNERS IN THESE CONTEXTUALLY BASED QUESTIONS?

In this section, I present some of the strategies used by learners in their responses to the examination task. I have identified four techniques from the data: Number Grabbing;

Guessing without Checking; Assumption Making and Scanning the Scenario to extract crucial information.

6.3.1 Number Grabbing

The number grabbing technique has been used by participants in this study to concoct solutions to the questions and/or the contexts they did not understand. For example, in response to determining the surface area of a socket, P2 grabbed numbers and substituted them into the given surface area formula. P5 did not know how to calculate ratio and arrived at the ratio 10:1 by grabbing the number from the previous Question 3.1.2. P9 was unable to interpret the graph, taking numbers randomly from the chart; he also grabbed numbers from the context in Question 1.3.3 and produced the mathematically unsound steps: 40 + 10% = 50 and 1.10% ÷ R180.00 = R12.79 for Question 3.3.1.

6.3.2 Guessing without checking

Another strategy used by learners was simply to guess without checking the feasibility or sensibleness of their response. When asked to determine the probability of infant deaths due to HIV/AIDS in 2004 based on a given table of information, P9 guessed an answer of 28%. Out of a choice of three stores offering different prices and discounts for a CD player in Question 5.1.4, P7 selected "Casanova because they offer higher discount". The learner's guess was not substantiated with calculations to justify her choice. For the same question, another learner (P8) chose Doggy Sounds to be the cheapest because it was the only store to exclude VAT. Her justification was based on an unfeasible reasoning that 'no VAT = cheaper price'. P7 gave a general response which was not true to Question 3.3.2 requiring two advantages of the Student Achiever account over the SUM account. This general response was more a guess which could have been given without reading the context.

6.3.3 Making Simplifying Assumptions

The data revealed that when the context or question was too complicated for learners, they resorted to simplifying the context by making assumptions to help them arrive at an answer. Evidence of this technique was observed in response to Question 3.1.3. P2 did not understand ratio and so simplified the problem by assuming Sipho earned less because he was younger and looked after animals for a shorter duration than Themba.

In Question 3.3.1 where learners were asked to calculate how much Themba will pay for withdrawing a cash amount of R180.00 from his account, P2 modified the question by assuming the withdrawal is from an ATM instead of doing a more difficult calculation of a cash withdrawal fee from the bank.

6.3.4 Scanning the Scenario without making sense

The findings revealed that learners often scanned the context information to identify crucial information without making sense of the context. For Question 3.2, although P4 knew that *"the cylinder and the bucket is not the same* (as the one he imagined as evident in his drawings during the interview) *because the bucket is bigger circle than the circle at the bottom and the cylinder got equal circles"*, he scanned the context and just used the formula of the cylinder given in the question. Even though P7 admitted that he did not think the given formula of the cylinder could be used to find the capacity of the bucket, he *"just used the formula"* and *"didn't really concentrate"* on whether the formula was appropriate to the context. P6 likewise did not judge whether the formula was appropriate or not. She simply detached herself from the scenario and just *"took the measurements of the cylinder and put it in the formula"*.

These findings show that learners did not place much importance in engaging with the contexts or in reasoning about the implications of certain tasks. They tried to find the easiest way to a solution without stopping to judge the reasonableness of their answers. This suggests that this examination setting was not an effective tool to promote learners' abilities in questioning, reasoning and making informed decisions.

Similarly, Reusser (2000) reported on students who readily "solve" insolvable, even absurd, problems presented to them, often without questioning the reasonableness of the problem. For example, the following nonsense problem from a French source (quoted from Reusser, 2000, p.23) was given to 76 first and third graders:

> *There are 26 sheep and 10 goats on a ship. How old is the captain?*

Despite its absurdity, more than three of four students produced a numerical answer to it. Another similar problem goes as follows:

There are 125 sheep and 5 dogs in a flock. How old is the shepherd?

The following is a quote from a fourth grade student working the problem out loud:

125 + 5 = 130 ... this is too big, and 125 - 5 = 120 is still too big ... while 125/5 = 25 ... that works ... I think the shepherd is 25 years old.

The "suspension of sense making" (Schoenfeld, 1991, cited in Reusser, 2000, p.24) implies that the classroom setting is not the ideal place for developing skills for life. Carraher, Carraher & Schliemann (1985, in Stern, 1996, p.154) also show that untrained children working in the market as vendors solved arithmetic problems embedded in a market context much better than problems embedded in a school-like context.

6.4 ANSWERS TO RESEARCH QUESTION 4: WHAT WERE SOME FACTORS THAT INHIBITED OR PROMOTED LEARNERS' SUCCESS IN THESE EXAMINATION TASKS?

6.4.1 Design of Examination Task

A document analysis of the examination task identified the design of the task itself to be one of the factors which affected learners' success in the task. The role of diagrams in the examination task as well as errors or inconsistencies in the question paper and marking memorandum were identified. The type of context, how learners experienced the context and the complexity of the context also affected the way learners responded to the examination task. An analysis of learners' responses identified poor conceptual knowledge or understanding; misconceptions; language-related misinterpretation of the questions and non-recognition of crucial information to be other factors that affected learners' success in these examination tasks.

a. The role of diagrams

The only diagram in the examination task was the three-part diagram in Question 1.2. Of the three sub-questions, only one required the use of the diagram, merely to extract the value of the height to substitute into the given formula for the calculation of the surface area of the socket. The complicated three-part diagram each with its own height 'confused' learners, resulting in the incorrect extraction of the value for the height. The diagram with its many dimensions affected learners' responses to the task, as noted by P9: "...there are like too much measurements to deal with" and "I was just writing what I know is right is right and carried on". Although P10 saw a socket before, "...when it's drawn up like this it doesn't seem..." like the socket he knows. This resulted in his incorrect reading of the height from Fig. B, the cube, as he did not know how the three figures fit together. Similarly, P5 knew what a socket was but still failed to extract the correct height from the diagram, indicating that the real thing and a diagrammatical representation of the socket made no difference in her understanding of the question. Mudaly (2010) also cautions that "If the question is difficult and beyond the experience of the student then whether diagrams were given or not is immaterial" (p.174).

The placement of the dimensions on the diagram is also important and can be misleading if incorrectly placed. L6 was misled into thinking the diameter of the socket was 5cm due to the placement of the 5 at the bottom side of the diagram (Fig. A). The bottom of the nut drawn with a curve (indicating the circumference) where the 5cm was placed, contributed to the confusion.

There was little confusion in obtaining the radius, r = 0.75, as 60 out of the 73 learners obtained it correctly because the "r" appeared in Fig. C and nowhere else in the diagram and thus could not be confused with other dimensions. The value of the diameter was also given in the stem of Question 1.2.1(a).

I would argue that the diagram in the paper was not necessary. Only one question required reference to the diagram i.e. to find the height of the socket which could have been given to learners as was the case with the diameter. Sometimes diagrams, as the case in this examination task, are included to "show that the context and, by implication, the underlying mathematics, is real" (du Feu, 2001, p.2).

Noonan (1990) described three types of illustrations in mathematics textbooks.

1. *Decorative* illustrations which are not related to the questions and serve no instructional purpose.
2. *Related* illustrations which have the same context as the questions and are used to support text and emphasise ideas.

3. *Essential* illustrations which are not repeated in the text, but the text refers to them, and they have to be read or worked with to answer the question.

The diagram of the socket in the examination paper contained information that was repeated in the text so it could not be an *essential* illustration. The diagram was not a *related* illustration as it did not support the text and emphasise ideas but created more confusion. Hence the diagram of the socket must have been placed merely for *decorative* purposes serving no instructional purpose.

b. Errors or inconsistencies in the examination task

The formula to calculate the surface area of a cylinder was incorrectly given as $SA = 2 \times \pi^2 \times r^2 + \pi \times d \times h$. Nowhere in their previous experience did learners encounter π as a value to be squared. The task designer may have assumed all learners to be using a scientific calculator and hence omitted the use of brackets in the formula to show the BODMAS rule. Learners who used non-scientific calculators were disadvantaged when their calculators displayed the incorrect answer.

The source document (growth chart) for Question 4.1 contained incorrect and misleading information with numbers which were unclear and difficult to decipher. The importance of clear information was made a very long time ago by Schutz (1961), who advised that symbols used on graphs need to be highly distinguishable, especially if they are in black and white. The questions that required the direct use of the growth chart, namely, Questions 4.1.1, 4.1.2 and 4.1.3, were among the worst answered question in the paper with 63%, 96% and 95% of learners respectively obtaining zero marks. The inclusion of 'girls' curves' with the 'boys' curves' was not possible on a single growth chart as the curves for boys and girls are different. The curves showing differences in boys and girls weight in the first two years was incorrect as both genders have the same growth curves for the first two years. In attempting to modify the growth chart to suit the question on girls' growth, the task designer in fact created confusion with learners and also himself. It was not possible from the given information to answer this question. The many incorrect curves, or perhaps incorrectly labelled curves, affected learners' responses to the examination task. The confusion was evident in the different areas learner looked for the values to work out the range. Ten learners read from the 50^{th} centile boys curve, 5 learners read from the 87^{th} centile boys curve, 9 learners used the 50th centile boys curve and the 87th centile boys' curves, and 13 learners used 87th centile boys curve and the 3rd centile girls curve.

The placement of text on the source document affected learners' success in the examination task. The 87th centile boys curve was obscured at the beginning with the text 5kg typed thereon. The break in the curve led learners to believe that the curve stopped at 5kg and hence read the curve from this point. The placement of the text '1 to 2 YEARS' led to learners reading off the incorrect value. Although many learners understood the concept 'range' as indicated in the interviews, the errors, incorrect information and distracters, in the inclusion of girls' curves in the source document hampered learners' success in the examination task.

6.4.2 The actual contexts used

Although performance varied across and within certain contexts, making it difficult to obtain general trends in performance in particular contexts, the qualitative analysis helped me to identify particular ways in which the contexts affected learners' engagement with the tasks. In terms of context, the factors that were identified were the type of context, the learners' experiences of the context as well as the complexity of the context.

a. Type of Context

The type of contexts did influence learners' performance. It was found that learners performed well in cleaned contexts probably because these contexts were more accessible to them. The worst performance was with contexts classified as real. Contrived contexts also posed a problem, probably because learners could not relate to contexts that were made up. The best performance was recorded by engagement with context free questions. Learners' performance declined on questions set at the higher level of Blooms taxonomy – questions involving multi-step procedures. There were variations in performance on questions based on the same context. This implies that there were other factors as well, apart from the context in which the questions were set, that affected learners' performance.

b. Personal Experience of the Contexts

Learners' own experience of the context and the real world influenced the way they interpreted and responded to the examination tasks. When asked whether the volume of the bucket would double if the dimensions were doubled, P10 responded 'Yes'. The respondent based his reasoning on his own experience of reality that a bigger bucket would be heavier to carry and not how the question designer intended him to reason. For a similar reason, Prestage & Perks (2001: p.107) argue that most of the time, a problem set in context "is hardly relevant to anyone other than the question setter".

The context about comparing two banks accounts (Question 3.3) also led learners to consider their own experiences in responding to some sub-questions rather than the given information. When asked to work out a cash withdrawal fee, P8 selected R0.00, which was influenced by the fact that the learner had an achiever account which did not charge an ATM withdrawal fee.

Owing to the fact that South Africa was to host the 2010 Soccer World Cup, there was lots of discussion about the various teams participating, who the good teams were and who would possibly win the World Cup. Learners' personal experiences and judgments about the performance of soccer teams influenced the way they answered Question 2.2.3(a). The question asked if South Korea could overtake Spain in the final round robin match. The correct response, based on the information given, was that if South Korea beat Spain in the final round robin match then both teams would be tied on equal points. Many participants, however, did not consider the given information, and responded that South Korea would not overtake Spain because Spain was a better team than South Korea. Their judgment was based on their real life experience of the teams' performance. P10, who was a follower of soccer and knew how the point system worked, was negatively affected by his personal judgment in Q2.2.3(a). His experience of the game and the point system, however, helped him to zoom in on the crucial information needed to accurately work out the points required in sub-questions 2.2.1 and 2.2.2.

In his study to understand how pupils interpret and respond to test items in the context of actual testing, Cooper (1998) found that "some children's accounts of their answers was a tendency to refer not to the given data but to their own experience of cars and lorries" (p.29).

He found that scores decreased as the children showed an increased tendency to refer to their everyday experience. Similarly, in my study, P8 and P10, as described in the preceding paragraphs, were negatively affected by their tendency to refer to their everyday experience of a bigger bucket being heavier and Spain being a better team than South Korea, rather than referring to the given data in responding to the examination task.

c. Complexity of the Contexts

The complexity of the contexts also affected learners' responses to the questions. Question 1.2.2, which required the number of 500ml tins of paint that would be needed to paint 1 200 nuts, given that 25ml of paint was needed to paint one nut, contained too many numbers which made the context complex for some participants. Some responses obtained were: 1 200 nuts ÷ 500ml; 25ml × 500ml; 500ml × 1 200 nuts. The question: 'How many…nuts?' gave participants the false perception that their response should be in terms of 'nuts' rather than 'tins'.

Due to the heavily information-laden context of Question 1.3 on wages and hours worked, Participant 9 gave up trying and simply multiplied the total working hours by the overtime rate. Similarly, participant 4 multiplied the total working hours by the normal rate. By subtracting a percentage from an amount (R708.75 – 1.3% = R707.45) and adding a percentage to hours worked (10% + 40 hours = 50 hours), participants demonstrated the complexity of the given context and the need to 'simplify it' in order to produce a response.

Participants 2 and 7 were unable to process multiple items of information simultaneously as was the case with Question 2.2 dealing with scoring in soccer. Multiple items of information that participants were required to deal with included the results from four matches and a log table showing matches won, drawn and lost with the points gained, Fifa's system of scoring, and the fanatic's system of scoring using bonus points. Due to the complexity of the information given in the scenario, Participant 2 responded in the interview: 'I'm not sure how they get points'. Although Participant 7 was able to use the crucial information to correctly calculate the points for South Africa (D) and South Korea (E), she was unable to re-calculate D and E using the fanatics system of scoring. Success in this question depended on whether learners could simultaneously consider multiple sets of data, and make judgements based on different possibilities. Cognitively, this is a high level instruction and although it can be classified as a Level 4 question in the SAML taxonomy (DoE, 2008, p.28), it is more demanding than the usual comparison task which asks for the better option based on comparison of prices or costs.

6.4.3 Learner Constraints

In addition to issues related to the design of the task and the context related issues, learners' success was also hampered by constraints of their own. Some constraints associated with learners were the poor conceptual knowledge of many learners, misconceptions that were revealed in their answers, language related misinterpretations of instructions and the failure of many learners to recognise crucial information needed to answer some of these questions.

a. Poor conceptual knowledge or understanding

Learners struggled with the mathematical concepts used in the examination task. Some of these concepts included the effects of multiplying and dividing by a whole number, the concept of ratio, volume, effects on volume when dimensions are doubled, range and scale drawing. One learner did not understand the concept that multiplication by a whole number increases its value, and division by whole number decreases its value, as was evident when P2 tried to convert 72 inches to centimetres using a given conversion table, by dividing by 2.56 instead of multiplying. Learners' poor conceptual knowledge of ratio was also evident when they used a comparison of ratios to explain that Sipho earned less than Themba instead of ratio to justify his answer, and when some did a calculation.

When dealing with the concept of volume, many learners did not show conceptual understanding of the concept as was evident in Question 3.2.3. A common mistake that learners make when dealing with 3-dimensional shapes is the belief that if the dimensions of the shape are doubled, the resultant volume will also double.

One learner misunderstood the meaning of the word "range" as shown in Question 4.1.2. Another example was learners inability to convert annual interest to a monthly interest rate. An analysis of learners' response has shown that poor conceptual understanding had in fact hampered learners' performance in the examination task. Resnick (1982) notes that "Difficulties in learning are often a result of failure to understand the concepts on which procedures are based" (p. 136).

b. Misconceptions

Three areas of misconceptions were identified in the study. To calculate the discount on an amount is relatively easy and would be classified as a level 1 question. To calculate the amount after the discount would require an additional step of subtracting the discount to the normal price. The idea is one of given the input, find the output. When the output is given and the input needs to be found in a multilevel task, the task becomes a higher order task. Question 5.1.3 is an example of such a task which required learners to calculate the price before the discount was added. This required a reversal or an inverse technique, normally the setting up of an equation which is mathematically more challenging. This explained why 97% of learners failed to score any marks for this question. The common misconception is to calculate the discount on the final amount and subtract it from the final amount. There was a misconception in the understanding that 8:1 meant eight times more as opposed to 2:1, which meant twice (double) more. Learners also misinterpreted the concept of ¼ when comparing discounts.

In their paper, Luneta and Makonye (2010) focus on analysing Grade 12 learners' errors and the misconceptions in calculus at a secondary school in Limpopo Province, South Africa. The analysis showed that most of the errors and misconceptions were due to knowledge gaps in basic algebra because learners failed to build procedures (know-how) from conceptual (know-why) knowledge. In my study, learners know the procedure to calculate a percentage of a number and hence are able to calculate the VAT of an amount. However, to calculate the original price of the item before VAT was included required conceptual knowledge (know-why), which some learners did not possess.

c. Language related misinterpretation of questions

"Contextual questions in examinations serve as barriers to some learners because of poor literacy levels and often prevent them from identifying the mathematical skills involved" (Sasman, 2011). Words like "deduction" in Question 1.3.2, "last week" in Question 1.3.1, "last" in Question 2.2.3, "margin" in Question 2.2.3(b), and "including VAT" and "excluding VAT" in Question 5.1.3 caused particular problems for learners and affected their performance in the examination task.

The word “deducted” in the scenario and “deduction” in Question 1.3.2 and the question setter’s further hint that deduct meant ‘subtract’, contributed to learners’ misinterpretation and thus affected their performance in the examination task. The phrase “last week” in the scenario implied Monday to Friday of the previous week (i.e. a total of five days); however, in the learners’ interpretation, “week” meant seven days they hence made their calculation on seven days instead of five.

The word “last” in Question 2.2.3 was found to be ambiguous and affected learners’ response to the examination task. The term as used in the context meant the final match and hence there was one remaining match to be played. Some learners (P3) interpreted ‘last’ as the previous match and thus there would be more matches to be played. This resulted in the learner suggested scores based on more than one match instead of only one match. Shorrocks-Taylow & Hargreaves (1999) explain how some familiar words could be used in unfamiliar ways or in different ways in different disciplines. For example, the word “solution” in mathematics would mean to find the solution to a problem, but in science the same word would mean to mix contents in a liquid form. Even the meaning of the word ‘margin’ in ‘win (by a margin of 1 goal)’ in Question 2.2.2 was not known to some learners. Question 5 posed problems to learners who did not know that ‘including VAT’ meant that VAT was already included in the price or whether the VAT had to be added to the price. Some of these language related misinterpretations were experienced by the second language speakers, which shows that they were disadvantaged because they did not understand the language. Dempster & Reddy (2007) found that more than 50% of learners from African schools chose option D from a multiple choice set of questions from the TIMMS study. Option D was the only one that contained a term that was found in the question (Atmosphere), suggesting that most English second language learners did not understand the question and merely selected an answer by matching words found both in the question and the answer. These language-related issues affected the way learners engaged with and responded to the tasks.

Evidence that complex terms and phrases affect student learning is documented in a study by Abedi & Lord (2001). These researchers tested about 1 200 Grade 8 learners on items from the National Assessment of Educational Progress (NAEP). Some of the items were rewritten in simpler language by rephrasing them, personalising them, and reworking or replacing conditional and relative clauses. The interview facet of the study showed that learners preferred the modified items as they felt them easier to comprehend and would choose them over the items worded in the NAEP if under duress. The performance facet of the study found that English language learner (ELL) and students of low socio-economic status (SES) performed significantly lower on the standard items than their English speaking or higher SES counterparts. The researchers also found that by modifying the items, the gap between the performance of English speakers and ELL as well as between learners of low SES and more affluent groups, decreased. These studies show that assessment designers must take steps to ensure that learners know what is being asked. Understanding the questions that are asked, is crucial for success in examination task.

Another language related issue experienced by all the learners was the use of the context-specific terminology such as “infant mortality rates”, This phrase was misinterpreted by all the learners, some of whom missed it because of its placement. The values represented deaths per every 1000 live births. Learners misinterpreted these values as percentages and actual number of infants who died. The misinterpretation is based on the fact that it is not a phrase that learners have encountered but is specific to the context. The task designer should have taken greater care that the meaning was easily available so the learners could be given the opportunity to reason and reflect on the results in the table. Context specific concepts such as ‘base occupancy’, ‘additional person supplements’, and ‘tariffs for an additional child’ used in a holiday context posed similar problems for learners in Khan’s study of the Grade 9 Learners experiences of the Common Tasks for Assessment (Khan, 2008).

d. Non-recognition of Crucial Information

Inability to recognise crucial information affected the learners’ responses to the examination tasks. Question 2.2.2 required learners to look at the log table and use the information provided on the number of goals scored by teams in each of the four matches to calculate the points gained according to the fanatics scoring system. Many learners failed to identify this crucial information and were unable to complete the calculation.

Question 4.2.1 required learners to calculate the number of babies who survived their first birthday. The figures in the table were based on the number of deaths per 1000 live births. This information was presented at the beginning of Question 4. Learners failed to identify this crucial information, with 73 learners failing to answer this question correctly. Many learners complained that the crucial information was too far away from where it was required.

Missing crucial information due to layout of the examination task is not peculiar to this study only. Ahmed & Pollitt (2000) in their study found that learners missed crucial information as a result of the layout of the task and that this in turn affected their performance in the task. In the subsequent interview, one learner responded: "I didn't realise it was the same question from before and I was thinking where's this boat from? I'd done the whole particle bit and then it asks you a question that relates to the bit before – I was thinking about particles and stuff rather than the other bit of the question – it tests how well you've actually read the thing – it's reading comprehension…and the number 2 makes you think it's a different question". In this case, the boat context was used in the first few parts of the question, followed by a general question in the second part about molecules. The student had lost track of the 'story' that was running through the question, and did not link this with previous parts (Ahmed & Pollitt, 2000).

The information presented in the scenario in Question 2.1 was not considered 'crucial' information by learners to complete the table of values showing the relationship between the number of workers and the time taken to complete the stadium. Values could be found through sequential number patterns. Since the preceding four sub-questions did not require any crucial information from the scenario, learners' did not consider the scenario to have any crucial information to answer sub-question 2.1.5, which actually required the crucial information about the time required to complete the stadium. The result was that learners based their response on the relationship between the number of workers and cost rather than the number of workers and time. Missing crucial information affected the way learners responded to the examination task. Khan (2008), in analysing learners' experiences with the Common Task for Assessment (CTA), found that learners missed 'crucial information' because of the overload of 'context information' (Bansilal &Wallace, 2008).

6.5 LIMITATIONS

The study was conducted with learners from a single school situated in a low socio-economic area and thus the findings cannot be generalised to all learners from all schools and different socio-economic levels.

The research interview was conducted in English. There may have been a possibility that English second language participants did not fully understand the questions posed during the interview, which may have affected their responses to some questions. Furthermore, having to express their responses in English meant that second language participants may have been unable to meaningfully express what they really wanted to say.

6.6 IMPLICATIONS OF THE STUDY

This study has identified errors in the examination task which is a huge concern. Firstly, these errors render those questions invalid, and should be disregarded when learners' performances are being evaluated. Furthermore, these examination tasks are seen by many people and are now in the public domain, where the questions will be used again. The errors also transmit wrong ideas by encouraging learners to use calculations which make no sense, fuelling an idea that the context does not need to be considered seriously. It would be advisable that a provincial paper such as the one examined in this study is moderated using the stringent criteria for national examination papers, so that when papers are released into the public domain, they do not serve as poor examples which become widely used.

The study has shown that the ways in which learners engage with contexts is a crucial issue in the examination. Thus the contexts chosen must be done with utmost care. The way in which the information about the context is presented is very important. This study identified two questions where learners missed crucial information because it was too far from the question. Also, contexts which are familiar may have the potential of leading learners to consider their own experience which may not be needed. Diagrams must be carefully chosen and only used to clarify or provide further information; otherwise they may confuse learners further. Tweaking real life data to suit a vague purpose such as in Q4, is not advisable. When formulae are given, then making sense of the context is not a priority of learners, and the question becomes reduced to a computation of the formula.

Another finding of the study was the prevalence of poor conceptual understanding as well as misconceptions of mathematical concepts. Considering that ML learners are more likely than mathematics learners to have had a poor background in fundamental mathematics taught up to the Grade 9 level, this finding makes sense. Many errors or misconceptions from learners' responses stem from poor conceptual understanding of foundational competencies taught in the earlier grades. Interventions to improve learners' performance should focus on knowledge, concepts and skills learnt in earlier grades and not only at Grade 12 level. However, it also suggests that the stipulation that ML must be taught in an intertwined manner using both contexts and content, is not always advisable. The DoE is adamant that one should not be taught without the other. Yet learners with weak cognitive ability in mathematics need help in understanding basic concepts of space, measurement, number and data handling, and they should be provided with a second chance of getting to know these concepts.

Some terminology used is this study also posed problems to learners who misunderstood them, and which affected their performance in the examination task. There is a need for test designers to carefully consider the terminology included within assessment items and for comprehensive analysis of student results.

It is my opinion that it is extremely difficult to assess learners' performance on real life contexts in an examination setting, as there may be as many diverse solutions as there are learners. The limitations of the marking memorandum may not take into account the diversity of responses. For example, a question such as the one below may elicit different responses:

> *A taxi can carry 15 learners. There are 123 learners in a school who are going on an excursion. How many taxis should the school hire?*

A purely mathematical solution which does not consider the context would be 8.2 taxis. The expected answer in the marking memorandum taking the context into account would be 9 taxis because one cannot get a fraction of a taxi. But how would one mark a response to a learner who says 8 taxis by providing an explanation from her experience that one can fit 15 learners in each of 5 taxis and then squeeze in 16 learners in each of the remaining 3 taxis? This is a scenario that would happen in reality, particularly in present-day South Africa. It is unlikely that a school would hire an additional taxi just for 3 learners! Hence if we want learners to engage with life related issues, we need to find alternate means of assessment rather than using examinations task. The examination setting creates pressure on learners to pass, and not to bother about making sense of what is being asked. The examination setting also restricts the kinds of authentic engagement that could help learners get to grips with real life issues.

6.7 SUGGESTIONS FOR FURTHER RESEARCH

A comparison of the performances of second language learners who have been taught in an English medium school from inception and those joining an English medium school later in their schooling career, may be undertaken in future studies.

Is an examination the most efficient way to assess whether learners have developed life related skills from studying Mathematical Literacy? It would be useful to know if an alternate model such as a project based programme or a set of extended investigations, would be a more productive use of learners' time than that spent learning how to answer ML assessment tasks.

6.8 CHAPTER CONCLUSION

This chapter addressed the four research questions posed at the end of Chapter Two by relating the findings in this study to similar findings in the literature review. It was found that more than half of the learners in the study performed poorly in contexts that were cleaned and contrived. The best performance was in context-free tasks and the worst performance was in tasks that were set in real life contexts. The study also found that the manner in which learners perceived and experienced the contexts influenced the way they responded to the task. There was not much difference in the performance of learners who found the context relevant or irrelevant. Number grabbing, guessing without checking, making assumptions and scanning the scenario to extract crucial information were strategies used by learners to respond to contextually based questions. Factors that affected learners' success in the examination tasks included the complicated nature of the diagram, misleading information, errors and unclear source documents in the examination tasks, as well as the type and complexity of the contexts and learners' personal experience with the contexts. Poor conceptual knowledge, misconceptions, language and non-recognition of crucial information also hampered learners' performance in the examinations tasks. Limitations of the study were outlined and possible recommendations concluded the chapter.

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APPENDIX A: September 2009 Preparatory Examination Question Paper and Marking Memorandum

Education

KwaZulu-Natal Department of Education
REPUBLIC OF SOUTH AFRICA

MATHEMATICAL LITERACY P2

PREPARATORY EXAMINATION

SEPTEMBER 2009

NATIONAL SENIOR CERTIFICATE

GRADE 12

MARKS: 150

TIME: 3 hours

This question paper consists of 10 pages and 2 Annexures.

INSTRUCTIONS TO CANDIDATES

1. This paper consists of 5 questions.
2. Answer **ALL** questions.
3. **ALL** the calculations must be clearly shown.
4. An approved calculator (non-programmable and non-graphical) may be used, unless stated otherwise.
5. ALL the final answers must be rounded off to TWO **decimal places**, unless stated otherwise.
6. Start each question on a **NEW page**.
7. Write neatly and legible.

QUESTION 1

A FACTORY LOST "AN ASSET" THROUGH STRIKE ACTION

John worked for a small steel factory (making bolts and nuts) in town. The factory received orders from different countries which used a measuring system known as the International System (IS) (e.g. foot, pints and inches) as opposed to the Metric System (e.g. cm, g, kg and litres) used in SA. John was an asset in the factory because he assisted in converting measurements from one system to another. He also taught other workers how to do conversions.

TABLE 1: CONVERSIONS.

International System		Metric System
1 Pint (pt)		569ml
1 foot(ft)		0,3048m
1 inch (in.)		2,54cm
1foot	12 inches	

There was a wage dispute last year which led to John's resignation.
The company is interested in finding a worker who has the same skills as John.

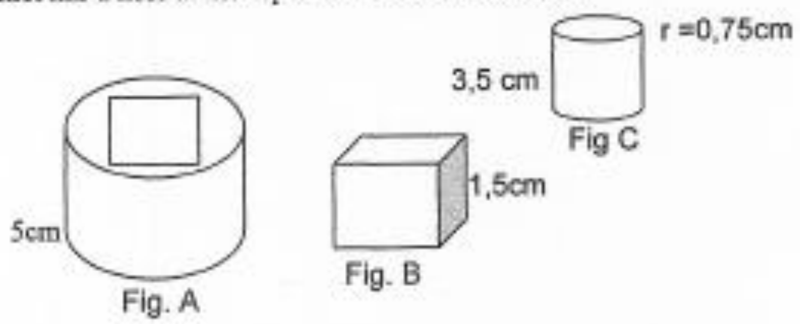
1.1 Let us assume you are employed in the position that John held. Demonstrate to your employers that you can be an asset too, by doing the following calculations:

1.1.1 How long (in cm) is a 72in. iron bar? (2)

1.1.2 How long (in m) is the above iron bar? (2)

1.1.3 You need ¾ of a 7ft iron bar. How many cm is the iron bar that is needed? (4)

1.2 The company makes and paints nuts better known as sockets like in fig. A. Fig. C shows the sockets (hole of a nut) at the bottom and Fig. B, the hole at the top. The hole at the bottom is cylindrical. The hole at the top is cubic. The socket has a hole at the top and a hole at the bottom.



1.2.1 (a) The nut has a diameter of 1,5cm

Calculate the minimum circumference of the iron that could be used to make this nut? Use this formula: $C = 2 \times \pi \times r$ (2)

(b) Calculate the surface area of the nut before the holes for the sockets are removed.

$$SA = 2 \times \pi^2 \times r^2 + \pi \times d \times h.$$ (4)

1.2.2 The whole nut must be painted grey, then decorated with white paint at the top and red at the base or bottom (holes are not painted). To paint one nut, you need 25ml of grey paint. How many 500 ml tins of paint will be needed to paint 1 200 nuts? (4)

1.3 John was paid R11,50 per hour. In his last week, he worked 9 hours a day, Monday to Friday. His employer deducted (subtracts) from his gross wages,1% for sick leave and 1,2% for Unemployment Insurance Fund (UIF).

1.3.1 Workers are allowed to work 40 hours a week at the normal rate, and above that, is regarded as overtime. They must be paid overtime at a rate of R15.75 per hour.
Calculate John's gross wages for the last week that he worked. (5)

1.3.2 Determine the deduction from John's wages towards his sick leave and UIF in his last week. (3)

1.3.3 John's employer was compelled by the trade union to increase their employees' wages by 10%.

The employer agreed to the 10% wage increase if the workers reduce their working hour by 10%. If John were still employed:

(a) Determine how many hours he would now work? (2)

(b) Is this a good decision? Substantiate your answer. (3)

[31]

QUESTION 2

During 2010 World Soccer Cup, the Eastern Cape province will host four teams. At present it has completed Three stadiums, TWO in Port Elizabeth and One in East London. But FIFA (world soccer governing body) has demanded that the stadium in Umtata must be completed for practice purposes. The government has decided to assist in completing the stadium at Umtata to meet the deadline of March 2010.

2.1 The amount of work left at this stadium at the beginning of September 2009 can be completed in exactly 4 months by 200 workers. The number of workers employed and the time taken to complete the stadium is given in TABLE 2 below.

TABLE 2: Number of workers and time taken.

No. of workers	400	320	**B**	200	**C**	125	100
No. of months	2	**A**	3,2	4	5	6,4	8

2.1.1 Calculate the numerical values of A, B and C. (5)

2.1.2 (a) Write down a formula or equation which can be used to determine the number of workers and months needed to complete the stadium in the form:

number of workers = ... (2)

(b) Use your formula to determine the number of workers needed to complete the work in 3,5 months. (3)

2.1.3 Use the graph paper provided on ANNEXURE A to draw a graph which illustrates the data in TABLE 2. (5)

2.1.4 Use the graph to answer the following:

(a) Approximately how many workers will be needed to complete the stadium in 6 months? (2)

(b) How long will it take 180 workers to complete the stadium? (2)

2.1.5 Would it be wise for the contractor building this stadium to save money by employing only 120 workers? Give a valid reason for your answer. (3)

2.2 During the first round, a group of FOUR teams play round-robin matches (each team will play against every team in the group). The top TWO teams proceed to the knock-out stage of the last 16 teams.

FIFA awards 3 points for a **Win**, 1 point for a **Draw** and no point for a **Lose**.

The log table shown in TABLE 3 below is based on the following results.

Match 1: Spain 3 , South Africa 3
Match 2: South Korea 2 , USA 2
Match 3: South Africa 1, USA 1
Match 4: Spain 4 , South Korea 2

TABLE 3: Log Table

COUNTRY	WIN	LOSE	DRAW	POINTS
Spain	1	0	1	4
South Africa	0	0	2	**D**
USA	0	0	2	2
South Korea	0	1	1	**E**

2.2.1 Spain, South Africa, South Korea and USA are in the same group. Using the FIFA awards system, calculate the numerical values.

(a) D (2)

(b) E (1)

2.2.2 Some soccer fanatics are proposing a new format of awarding points, based on the following:

Proposed Format: Win (by a margin of 1 goal (e.g. 1- 0, or 2-1 , 3-2) = 3 points

Win (by a margin of 2 or more goals (e.g. 2-0 or 4-1) = 3 + 1 bonus point
Draw of less than 2 goals (0-0 or 1-1) = 1 point
Draw of 2 or more goals = 1 + 1 bonus point
Lose by a margin less than 2 goals = 1 bonus point
Lose by more 2 or more goals = no points

(a) Using the new format, how many points will a team have if it has won one match (4 – 2) and drew another match (2-2) ? (3)

(b) Determine the values of D and E in TABLE 3 if the points awarded were based on the Soccer fanatic's new proposed scoring method. (4)

2.2.3 The last round robin matches will be Spain against USA, and South Africa against South Korea.

(a) Using the FIFA scoring format, is it going to be possible for South Korea to overtake Spain? Give a reason for your answer. (3)

(b) South Africa and USA need a total of 6 points to guarantee their places in the next round. Suggest any score that will enable South Africa to move to the next round, using the soccer fanatic's scoring system. (4)

[39]

QUESTION 3

Themba and Sipho spend their school holidays working for different farmers to earn pocket money.

3.1 Suppose that during December holidays Sipho was paid R60 a week for looking after 48 animals and Themba was paid R100 for looking after 96 animals.

3.1.1 How much does Sipho earn for looking after one animal? (2)

3.1.2 If the farmer adds another 10 animals how much is he now going to earn? (2)

3.1.3 Sipho complained that he earns less than Themba. But he was told that they earn equal amounts . Is that correct ? Substantiate your answer by showing a ratio of their income to livestock. (3)

3.2 As part of his duties Sipho has to collect 10 cows from the veld and milk them before releasing the cows at 08H00. He must use a bucket with a round base of radius 10cm and a height of 25cm for each cow.
It takes him 15 min to milk each cow and pour the milk into a bigger container in the farmer's house.

3.2.1 At what time must Sipho start milking the cows to finish milking all 10 cows before 08H00? (3)

3.2.2 Determine the maximum capacity (inℓ) of the bucket used by Sipho if

$$1m^3 = 1000\text{liters}$$

and **Volume of cylinder =** $\pi \times r^2 \times h$ (4)

3.2.3 Sipho decided to reduce the time spent on walking to carry the milk to the farmer's house, by first pouring milk from each cow into a larger second bucket.
The dimensions of the second bucket is **double** the dimensions of the first bucket.

(a) Using this second bucket, do you think Sipho will double the amount of milk he is takes to the farmers house per trip? (1)

(b) Prove your answer in (a) by calculating the ratio of the volume of the new bucket to the volume of the old bucket. (5)

3.3 Sipho and Themba are paid weekly and save at least 75% of their money in accounts called SUM[1] and Student Achiever, respectively. The price list for withdrawals and deposits is as follows.

TYPE OF TRANSACTION (WITHDRAWAL OR DEPOSIT)	(SUM)[1]	STUDENT ACHIEVER
Minimum Balance	R20,00	R0,00
Deposit (cash)	R3,50 + 1,03% of value deposited	
Withdrawal (cash)	1,10% of the value withdrawn	
Withdrawal (cheque)	R13,00 + 1,10% of value of cheque	1,10% of value of cheque (minimum R21,00)
Maestro Usage **(Purchasing using a card)**	R2,15	R3,50 +0,70% of value;(maximum of R15,80)
Trying to withdraw more money than you have in your account	At Standard bank =Free At another bank's ATM =R3,65	

After analyzing the price list of different accounts offered by the bank, Themba decided to open the Student Achiever Account.

3.3.1 Calculate how much Themba will pay for withdrawing a cash amount of R180,00 from his account.. (2)

3.3.2 Themba had a balance of R111,00 in his account. His father then deposited a sum of R380,00. Determine the new balance that will appear in his account, noting that he has to pay a cash deposit fee. (4)

3.3.3 Provide any TWO advantages of choosing the student achiever account. (4)

[30]

QUESTION 4

Between 2004 and 2008 research was conducted to assist the government in identifying causes of the high infant mortality rate (i.e. the number of infant deaths during the first year of life per thousand live births). The researchers monitored the Growth Charts of babies as in Annexure B. The trend in Growth Charts of babies who were not going to die before their first birthday was totally different from the Growth Chart of Peter (Annexure B).

4.1 The graph in Annexure B shows the percentiles in babies' Growth Chart.

4.1.1 What is the normal weight of the baby boy at birth? (2)

4.1.2 Determine the range of baby boys' masses at birth. (2)

4.1.3 What will be the mass of a healthy 2 year-old girl who weighs 2,5kg at birth? (2)

4.1.4 Peter weighed at 50^{th} percentile at birth. When he was 3 years, he weighed 13 kg as indicated.

(a) What does 50^{th} percentile mean? (2)

(b) Is Peter's weight normal as compared to other 3-year old boys? Give a reason for your answer? (3)

(c) Provide any TWO causes for this change in Peter's mass from 33 months to 36 months ? (4)

4.1.5 Do you think that using Growth Cards can save the lives of infants? Substantiate your answer. (3)

4.2 This table shows the statistics of infant mortality between 2004 and 2008 due to different illness .

Year	Polio	Measles	HIV-Aids	Hep. B
2004	2	1	5	0,8
2006	1,8	1,2	3	0,9
2008	1	1,1	3	1

4.2.1 If there were 18 000 children born in 2004, how many babies (according to this report) were going to reach their first birthdays? (5)

4.2.2 What is the probability that the death was due to HIV –Aids in 2004. (2)

4.2.3 Which disease is responsible for the infant deaths from 2004 to 2008? (2)

4.2.4 Some observers were happy about the trend of mortality (death) caused by HIV-Aids. Explain this trend and supply a possible reason for it. (4)

[31]

QUESTION 5

> Your brother wants to buy a CD / VCR Combo player of a well known brand called Sansui. He got the following quotations from 3 different shops.
>
> - Blue Gum offers 19% off normal price of R1 299 including VAT
> - Casanova offers ¼ off normal price of Price including VAT
> - Doggy Sounds offers R989,99 excluding VAT.

5.1 Your brother came to you to ask for assistance in identifying the shop which has a better price.

5.1.1 Calculate the discount offered by Blue Gum. (2)

5.1.2 If the discount offered by Casanova is R324,75 calculate the original price of the CD/VCR Combo player. (3)

5.1.3 Determine the price of Blue Gum CD player excluding VAT before the discount is calculated. (3)

5.1.4 If your brother had the money to buy a CD player, at which store would he purchase the CD player? Give a reason for your answer. (3)

5.2 Your younger brother was presented with R400 for passing Grade 10 and decided to invest it to buy his own CD player for use when he is at a tertiary institution. Calculate how much he will have after 3 years if he is paid an interest rate of 8% p.a. compounded monthly.

Use this formula: $A = P(1 + i)^n$, where

P = amount invested

i = monthly interest rate as a decimal

n = number of months the money is invested for (5)

5.3 If the size of the front face of the CD player is 45cm x 30cm. Use the following scale to **draw** the space taken by its picture in the advert of Doggy Sounds.
Scale 1 : 10 (3)

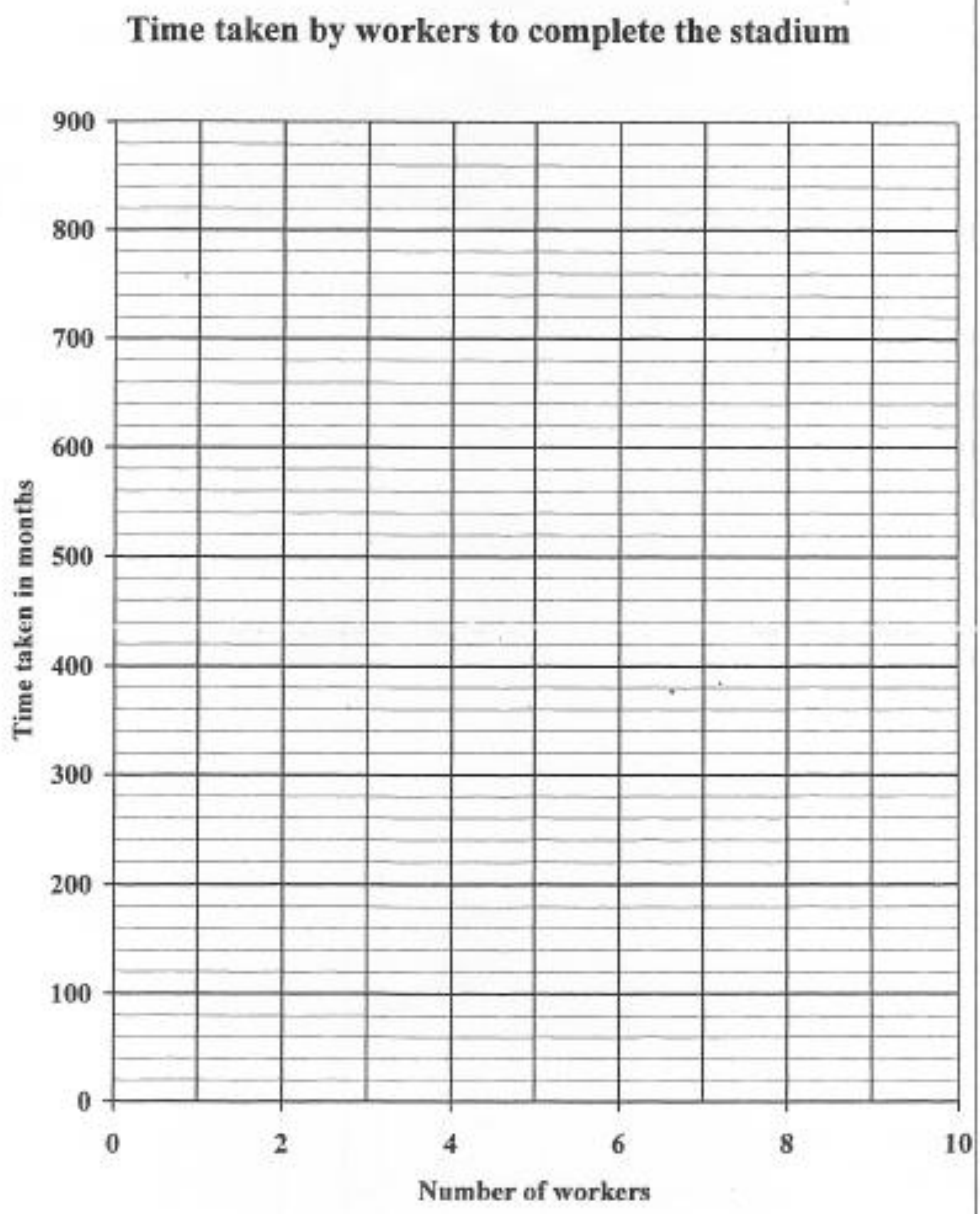
[19]

<u>GRAND TOTAL</u>: 150

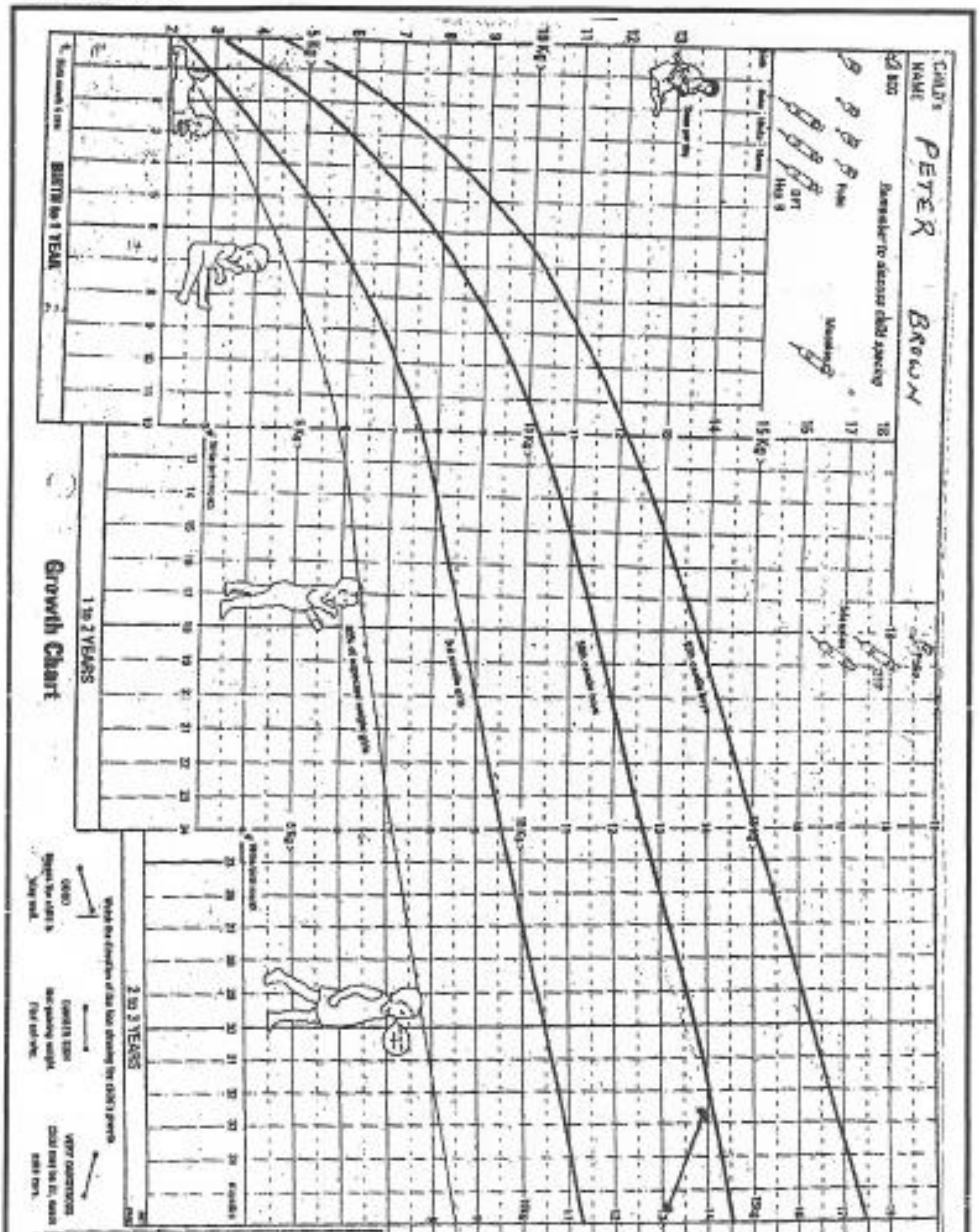
ANNEXURE A **NAME:** ____________________

QUESTION 2.1.3

PLEASE TEAR ON DOTTED LINE



ANNEXURE B


CHILD'S NAME
PETER BROWN
BIRTH to 1 YEAR
1 to 2 YEARS
2 to 3 YEARS
Growth Chart

Education

KwaZulu-Natal Department of Education
REPUBLIC OF SOUTH AFRICA

MATHEMATICAL LITERACY P2

MEMORANDUM

PREPARATORY EXAMINATION

SEPTEMBER 2009

NATIONAL SENIOR CERTIFICATE

GRADE 12

MARKS: 150

TIME: 3 hours

This question paper consists of 11 pages.

SYMBOL	EXPLANATION
A	**Answer / Accuracy**
M	**Method**
CA	**Consistent Accuracy**
MA	**Method with Accuracy**
SF	**Substitution**
O	**Opinion**
R	**Rounding Off / Reason**
C	**Conversion**

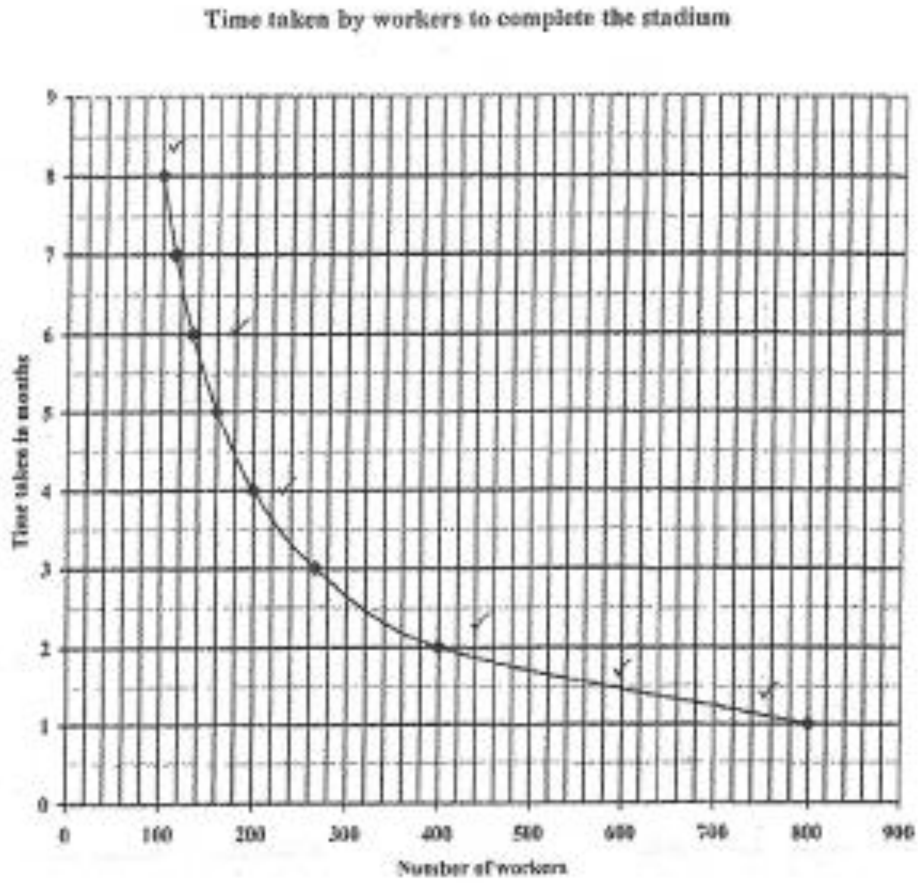
NO	AS	CALCULATIONS / WORKINGS	MARKS/ COMMENTS
1.1.1	12.3.2	1in. = 2.54 cm 72 in. = 72 x 2,54 cm✓ = <u>182,88 cm</u>✓	1 = MA 1 = A (2)
1.1.2	12.3.2	$\frac{182{,}88 \text{ cm}}{100✓}$ = 1,83m✓	1 = CA 1 = M (2)
1.1.3	12.3.2	¾ of 7 ft = 5,25ft ✓ = 5,25 x 12 x 2.54✓✓ = <u>160 cm</u>✓	1= A 1= C 1= A 1CA (4)
1.2.1 (a)	12.3.1	C = 2π x r $= 2 \times \pi \times \frac{1{,}5}{2}$ cm✓ = <u>4,71 cm</u>✓	1 = SF 1 = A (2)
(b)	12.3.1	SA of cylinder $= 2\pi \times r^2 + \pi \times d \times h$ $= 2(\pi)(\frac{1{,}5}{2}\text{m})^2$ ✓+ π x 1,5cm x 5cm ✓ = 3,53 cm^2 + 23,55 cm^2 ✓ (grey surface) = <u>27,08 cm^2</u> ✓ *NB: Error on Q: $(\pi)^2$ 2 Marks subst. + 2 Marks for error* *Wrong answer* = 11,09 + 23, 55 = 34,64cm^2	2 = SF 1 = A 1=CA

1.2.2	12.3.2	1 socket = 25ml 1 200 socket = 25 x 1 200✓ = <u>30 000ml</u>✓ No. of tins = <u>30 000ml</u> / 500ml✓ = 60 tins✓	1 = MA 1 = A 1 = MA 1 = CA (4)
1.3.1	12.1.3	Wages = R11,50 x 40 hrs✓ = R460,00✓ Overtime: 45hours – 40 hours = 5 hours Overtime wage = 5 x R 15,75✓ = R78,75✓ Total = R460 + 78,75 = R538,75✓	1 = MA 1 = A 2 = M 1 = CA (5)
1.3.2	12.1.3	Total deduction = 1% + 1,2% = 2,2% ✓ ∴ Deduction = $\frac{22}{100} x \frac{R538,75}{7}$ ✓ = R11,85✓ CA	1 = M 1 = CA 1 = CA (3)
1.3.3 (a)	12.1.1	45 hours - 10% of 45 hours = 40,5 hours✓✓ **OR** 9 hours – 10% of 9 Hours = 8,1 hours per day	1= A 1=CA (units) (2)
1.3.3 (b)	12.1.3	Yes ✓, because he reduced wages of his workers✓✓ any other valid point **OR** No, is unfair to workers because their weekly wages were not increased. **OR** any other valid point	1 =yes 2 =O **OR** 1 = no 2 = O (3)

QUESTION 2

2.1.1	12.2.1	$A = \frac{800}{320}$ ✓= 2,5 ✓ $B = \frac{800}{3,2} = 250$ ✓✓ $C = \frac{800}{5}$ = ~~400~~ ✓160	2 = M 3 = A (5)
2.1.2 (a)	12.2.1	Number of Workers = $\frac{800}{\text{months}}$ ✓✓	2 = A (800/ months) (2)
2.1.2(b)	12.2.1	Number of Workers = $\frac{800}{3,5}$ ✓ = 229 workers✓✓	1 = SF 1 = CA 1 = C (3)

2.1.3



3 M plotting points, 1 M joining points, 1 CA overall shape (5)

NB: *Graph axes on Question paper; reversed. Mark positively according to candidates answer.*

2.1.4 (a)	12.2.3	134 workers ✓✓ Accept any answer between 130 and 135 *NB: Mark from candidate's graph.*	2 = reading from graph (2)
2.1.4 (b)	12.2.3	$4\frac{1}{2}$ months ✓✓ *NB: Mark from candidate's graph.*	2CA = reading from graph (2)
2.1.5	12.2.3	No✓, because they will not meet complete the stadium in time.✓✓	1 = No 2 = R (3)
2.2.1 (a)	12.4.2	D = 2 ✓✓	2 = A (2)
2.2.1 (b)	12.4.2	E = 1 ✓	1 = A (1)
2.2.2 (a)	12.4.2	3✓ + 1✓ + 1 + 1 = 6✓	1 = M 2 = A (3)
(b)	12.4.2	D = 1 + 1 + 1✓ = 3✓ E = 1 + 1✓ = 2✓	2 = CA 2 = CA (4)
2.2.3 (a)	12.4.4	No✓, Because according to FIFA format, a team gets 3 points for a win so it will end up with ~~5~~✓ 4 points✓ which is the same, should Spain lose.	1 = No 2 = R (3)
2.2.3 (b)	12.4.2	2.2.4 South Africa 2 ✓– South Korea 0✓ or 3-1, 4 – 2, 3 – 0 or any other score with a margin of more than 2 goals. D = 2 + 3✓ Total points = 2 + 3 + 1 = 6✓	4 = A (4)

SA drew with Spain (3-3) = 1 pt + 1 bonus pt

SA drew with USA (1-1) = 1 bonus pt

TOTAL = 3 points

SA needs 3 more points

∴ SA need only a win.

possible scores: 1-0, 2-1, 3-2, etc.

QUESTION 3

3.1.1	12.2.1	60 / 48✓ = R1,25✓	1 = M 1 = A (2)
3.1.2	12.2.1	R1,25 x 58✓ = R R72✓,50	1 = CA 1 = A (2)
3.1.3		3.1.3 No ,✓ 48 : 60 = 4 :5 ✓ **OR** 20 : 25 96 : 100 = 24 : 25✓	1 = No 2 = A (3)
3.2.1	12.3.1	Time need = 10 x 15 minutes = 150 minutes ✓ At 05H30✓✓	1= M 2 = A (3)
3.2.2	12.3.2	3.3.2 **Capacity of bucket** = $\pi \times r^2 \times h$ $= \pi \times (10cm)^2 \times 25cm$ $= 7853,98cm^3$✓ Litres of Milk $1m^3 = 1000$ litres ✓ $0,00785\ m^3$ = litres litres = 0,00785 x 1000 = <u>7,85 litres</u>✓	1 = M 1 = Volume of bucket 1 = using scale 1 = A (4)
3.2.3	12.3.1	(a) No✓ (b) **Capacity of new bucket** = $\pi \times r^2 \times h$ $= \pi \times (20\ cm)^2 \times 50\ cm$✓✓ = 62 831,85✓ <u>Ratio:</u> volume of new bucket: volume of old bucket 62 831,85 : 7 853,98✓ = 8 : 1✓ Therefore, new capacity is more than double the size of the first particular age.	1 = A (1) 2 = doubling dimensions of the bucket 1 = volume of bucket 1 = M 1 = C (5)
3.3.1	12.1.2	1,10% of R180 ✓= R1,98✓	1 = SF 1 = A (2)
3.3.2	12.1.2	Fees = R3,50 + 1,03% of R380✓ = R3,50 + R3,91 = R7,41✓ Balance = R380 + R111 – R7,41✓ = R483,59 ✓	1 = M 1 = A 1 = M 1 = CA (4)
3.3.3	12.1.3	There is no minimum balance✓✓ No management fee ✓✓	2 X 2 = R (4)

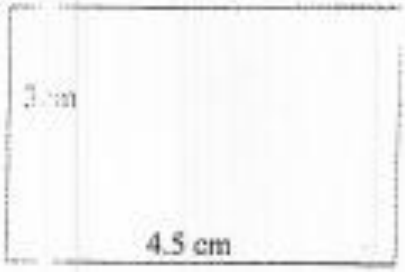
QUESTION 4

4.1.1	12.4.1	≈ 3,2 kg (accept any answer between 3 kg and 3,5 kg)✓✓	2 = R (2)
4.1.2		Range = 4,5 kg – 2,2 kg ✓ = 2,3 kg ✓	1 = M 1 = CA (2)
4.1.3		≈ 9,5kg ✓✓	2 = R (2)
4.1.4	12.4.1	(a) Means half of boys normally weight that particular kg at that particular age.✓✓ (b) No✓, since it is mentioned in the card if the graph is that direction, there is something wrong✓✓ (c) – he was sick and did not like food✓✓ – he started walking and as result lost some wait.✓✓ – His mother gone back to work and does not mother's milk. **Or** any other valid point	2 = R (2) 1 = No 2 = R (3) 2 x 2 = 4 (4)
4.1.5		Yes.✓ Loss of weight can be an indication that the child is sick.✓✓ **Or** any other valid point	1 = A 2 = R (3)

4.2.1	12.4.2	(polio deaths) $= \frac{18000}{1000} \times 2 = 36$✓ (Measles deaths) $= \frac{18000}{1000} \times 1 = 28$ 18 ✓ (HIV-Aids deaths) $= \frac{18000}{1000} \times 5 = 90$✓ (Hep. B deaths) $= \frac{18000}{1000} \times 0{,}8 = 1{,}44 = 1$ 14,4 Number of babies $= 18\,000 - (36 + 28 + 90 + 1)$✓ (18, 14.4) $= 18\,000 - 155$ 158 $= 17\,845$✓ 17842	1= MA 1 = A 1 = A 1= M 1 = CA (5)
4.2.2	12.4.5	P(HIV-AIDS) $= \frac{90}{18000}$✓ $= 0{,}005$✓ or 0,5%	1 = M 1 = A (2)
4.2.3	12.4.3	Hep. B✓✓ *NB: Mark according to candidates interpretation*	2 = CA (2)
4.2.4	12.4.4	The death of infants due to this disease is decreasing or stable✓✓ Reason: Most pregnant mothers are given ARVs✓✓ or Less people are infected with HIV due to knowledge of the disease. or Most people are now faithful to their partners or better medication are used to help infants born with HIV **Or** any other valid point	2 = O 2 = O (4)

QUESTION 5

5.1.1	12.1.3	Discount $= \frac{19}{100}$ of R1 299✓ = R246,81 ✓	1 =MA 1 =A (2)
5.1.2	12.1.3	Original price = 4 x discount ✓ = 4 x R324,75 ✓ = R1 299,00 ✓	1 = M 1 = A 1 = CA (3)
5.1.3	12.1.3	Price before VAT = $\frac{100}{114}$ ✓ x R1 299✓ = R1 139,47✓	2 = M 1 = A (3)
5.1.4	12.1.3	He must buy from Casanova✓ Casanova charges = 3 x R324,75 = R 974,25✓ which is the lowest price.✓ **OR** any suitable calculation	1 = A 2 = R (3)
5.2		P = R400 $n = 3 \times 12 = 36$✓ $i = \frac{8}{100} \div 12$ ✓ $A = P(1 + i)^n$ $= R400(1 + \frac{8}{100} \div 12)^{36}$ ✓✓ = R 508,09✓	1 = A 1 = A 2 = M 1 = CA (5)

5.3	12.3.3		1 = exactly 3cm breadth 1 = exactly 4,5cm length 1 = right angles (3)

<u>GRAND TOTAL</u> : [150]

APPENDIX B: Ethical Clearance

UNIVERSITY OF
KWAZULU-NATAL

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26 January 2011

Mr R Debba
School of Education and Development
EDGEWOOD CAMPUS

Dear Mr Debba

PROTOCOL: An Exploration of the strategies used by grade 12 mathematics literacy learners when answering mathematical literacy examination questions based on a variety of real-life contexts
ETHICAL APPROVAL NUMBER: HSS/0010/2011 M: Faculty of Education

In response to your application dated 21 January 2011, Student Number: **832037S** the Humanities & Social Sciences Ethics Committee has considered the abovementioned application and the protocol has been given **FULL APPROVAL.**

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

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

Yours faithfully

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

SC/sn

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

APPENDIX C: An Analysis of Learner's Marks per Question – Trial Examination 2009 Paper 2

Question Number	Maximum Mark	Names of Learners(73)																																				
		NKa	MSe	GCt	GS	MD	NNe	KS	PL	MJ	MP	KF*	EF*	GY	PK	Msa*	JN	NNi	PH*	BB	SSi	CR	MJu	Nke*	MRm	PD	LM	NB*	SSa	RN	NNa	PT	NT	RP	MZ	EN	CE	BS	VK	MNi
1.1.1	2	2	2	2	2	2	0	2	2	2	2	2	2	2	0	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	0	0	2	2	2	2	1	2
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1.1.3	4	4	4	2	4	2	0	4	2	2	4	4	3	1	1	4	3	4	4	0	1	0	2	3	4	1	1	0	4	4	0	2	2	1	3	2	3	4	2	2
1.2.1(a)	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	0	2	2	0	2
1.2.1(b)	4	4	1	2	1	2	4	1	4	1	0	1	1	4	4	0	4	1	1	1	1	1	1	1	2	4	1	4	1	4	4	1	1	2	4	1	1	4	0	4
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1.3.3(a)	2	0	0	2	2	0	2	2	0	0	2	2	2	2	1	0	0	2	2	1	0	1	0	0	0	2	0	0	2	1	2	0	0	0	0	0	0	2	2	0
1.3.3(b)	3	3	3	1	3	3	3	3	3	1	3	3	3	3	2	3	3	3	3	1	1	3	1	1	3	3	3	1	3	1	3	1	3	1	3	1	3	3	3	0
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2.1.2(a)	2	2	0	0	2	2	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
2.1.2(b)	3	3	0	0	3	0	1	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	3	0	3	0	0	0	0	0	0	0	0	0	0
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2.1.4(a)	2	2	2	2	2	0	2	2	0	2	2	0	2	0	2	2	0	0	2	0	2	0	2	2	0	0	2	0	0	0	2	0	0	2	0	0	0	2	0	2
2.1.4(b)	2	2	2	2	2	0	2	2	0	2	2	0	2	2	2	2	0	0	2	0	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0	2	0	2	0	2
2.1.5	3	3	3	3	3	3	3	3	0	3	3	0	0	3	3	3	0	0	3	3	3	3	3	0	1	3	3	3	3	0	0	3	3	0	3	0	0	0	0	3
2.2.1(a)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2.2.1(b)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
2.2.2(a)	3	2	3	3	0	3	3	2	3	3	3	2	2	3	1	3	3	0	3	3	3	3	3	3	3	3	3	2	2	2	3	0	3	2	2	2	1	2	2	3
2.2.2(b)i	2	0	0	2	2	2	2	0	2	2	0	2	0	0	0	2	2	2	0	0	2	2	2	0	2	0	2	2	0	0	0	2	2	2	0	2	0	1	2	0
2.2.2(b)ii	2	2	2	2	2	0	0	0	0	2	0	2	2	2	0	2	2	2	2	0	2	2	2	2	0	2	2	2	0	0	2	2	2	0	2	0	2	2	2	0
2.2.3(a)	3	1	1	2	1	1	1	0	1	3	1	2	1	3	3	3	1	2	1	1	3	0	3	0	3	0	1	1	1	0	1	1	1	1	3	0	1	0	1	1
2.2.3(b)	4	4	2	2	0	0	4	0	3	4	2	2	4	4	0	0	2	2	2	0	2	2	2	4	2	0	1	2	2	2	2	2	2	0	4	2	2	0	4	0
3.1.1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
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3.2.1	3	3	1	3	3	3	3	3	1	3	1	3	3	3	1	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	0	2	1	3	3	3	1	3	3
3.2.2	4	1	2	2	1	2	2	1	2	1	2	2	1	1	1	2	1	1	0	2	1	2	1	2	4	1	2	2	2	2	4	2	0	2	2	0	0	0	2	2
3.2.3(a)	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
3.2.3(b)	5	1	2	2	0	5	5	1	2	1	0	2	5	1	0	2	0	1	0	5	1	0	0	0	3	1	0	3	0	0	0	0	0	0	2	0	2	0	2	0
3.3.1	2	2	2	2	2	2	2	0	2	0	2	2	2	2	2	2	2	2	0	2	2	2	2	1	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3.3.2	4	3	4	4	4	3	4	2	4	3	4	4	4	4	4	1	4	4	0	4	1	4	2	4	0	4	1	0	0	0	3	4	4	4	3	0	0	2	4	0
3.3.3	4	4	4	4	2	4	2	0	2	2	4	4	4	4	4	4	4	2	2	4	0	4	4	4	2	4	2	4	2	4	2	2	4	4	4	0	4	0	0	0
4.1.1	2	0	2	0	2	2	0	0	2	2	0	2	2	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	2	2	0	0	2
4.1.2	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
4.1.3	2	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
4.1.4(a)	2	2	2	0	2	2	1	0	0	0	2	2	2	0	0	2	0	2	1	2	1	2	1	2	0	1	2	0	0	0	0	1	2	0	0	1	0	0	2	0
4.1.4(b)	3	3	1	3	3	1	3	3	3	3	0	3	3	3	3	3	3	2	3	3	3	3	1	3	3	0	1	0	2	3	3	3	0	3	0	1	0	1	3	3
4.1.4(c)	4	4	4	4	4	4	4	4	4	4	4	4	4	0	4	4	2	0	2	4	4	2	2	2	0	2	0	4	4	0	0	2	0	2	0	4	4	0	4	4
4.1.5	3	3	3	3	3	3	3	0	3	0	3	3	3	0	3	3	3	3	3	3	3	3	3	3	1	0	0	3	3	3	0	3	3	3	3	3	3	3	3	3
4.2.1	5	3	3	1	3	3	3	0	1	2	3	3	1	2	3	3	1	3	1	0	0	2	0	1	0	1	0	0	0	0	1	3	0	4	0	0	0	2	0	2
4.2.2	2	0	1	1	1	1	0	0	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.2.3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	0	2	2	2	0	2	2	2	2	2	2	2	2	2	2
4.2.4	4	2	2	4	4	4	2	4	2	2	2	4	4	2	2	2	4	4	0	2	4	2	0	4	3	4	2	0	4	0	0	2	0	0	2	4	2	4	0	0
5.1.1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5.1.2	3	3	3	3	3	3	0	3	3	3	3	0	3	3	0	0	0	3	3	3	0	0	3	3	3	2	3	0	0	0	0	0	0	0	0	3	3	0	0	0
5.1.3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.1.4	3	0	3	3	0	0	0	3	0	3	3	0	0	0	0	3	0	3	3	3	3	0	0	3	0	0	0	0	0	0	2	0	0	0	0	3	0	3	0	0
5.2	5	0	3	0	0	0	0	2	0	2	2	2	0	0	2	0	2	2	2	2	0	2	2	2	2	0	0	0	2	2	2	0	5	0	2	0	0	2	0	0
5.3	3	3	3	3	3	3	0	3	3	0	3	0	0	3	0	0	3	3	0	0	3	2	0	2	1	3	0	0	3	0	0	0	3	3	0	3	0	0	3	0
TOTALS	150	107	104	104	102	99	98	95	94	94	94	94	93	92	91	90	88	86	84	83	83	83	82	81	80	79	78	77	76	75	75	74	73	73	72	72	70	69	68	68
%	100	71	69	69	68	66	65	63	63	63	63	63	62	61	61	60	59	57	56	55	55	55	55	54	53	53	52	51	51	50	50	49	49	49	48	48	47	46	45	45

Question Number	Maximum Mark	Names of Learners(73)																																		Average	Median	Mode	Zero Marks	Part Marks	Full Marks
		MA	MS*	SSh	MW	MRo	GN	GCa	VS	NL	GR	ML	HSi*	HN	SSb	MT	HSh	PSu	MNm*	CS	MMe	MB	LL	NNh	MRe	NA	NM	RT	HB	PV	PSa	DN	MNe	MMb	BA*						
1.1.1	2	2	2	0	2	0	2	2	2	0	0	1	2	2	2	0	2	0	2	0	0	0	0	0	2	0	2	0	0	2	2	0	0	0	0	1	2	2	31.5	2.7	65.8
1.1.2	2	2	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	2	0	0	0	0	1	0	0	58.9	0	41.1
1.1.3	4	4	3	1	2	1	0	1	3	0	4	0	1	0	0	0	1	1	0	0	0	1	1	1	0	0	0	0	1	1	0	1	1	0	1	2	1	0	27.4	52.1	20.5
1.2.1(a)	2	2	2	2	2	2	2	2	2	2	0	0	2	2	2	0	2	2	0	2	0	0	0	2	0	2	2	0	2	0	2	0	0	2	0	2	2	2	24.7	0	75.3
1.2.1(b)	4	4	0	0	4	4	0	0	4	1	1	1	1	1	1	1	1	4	0	1	0	0	0	1	1	1	4	2	1	0	1	1	0	2	0	2	1	1	19.2	54.8	26
1.2.2	4	0	4	0	4	1	0	4	2	2	1	0	0	4	0	2	0	4	0	0	0	4	4	0	2	0	0	0	0	4	0	0	4	0	0	2	4	4	35.6	11	53.4
1.3.1	5	5	0	3	3	1	4	1	2	0	0	0	0	0	0	5	0	5	0	2	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3	3	5	37	21.9	41.1
1.3.2	3	3	0	0	0	0	0	0	0	2	0	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	39.7	27.4	32.9
1.3.3(a)	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	71.2	8.2	20.5
1.3.3(b)	3	3	1	1	1	1	3	1	1	1	1	1	1	0	3	1	3	1	3	3	3	2	1	1	1	3	1	1	1	1	1	3	1	1	0	2	2	3	4.1	47.9	47.9
2.1.1	5	0	5	2	0	2	5	0	0	4	3	2	2	0	0	5	2	0	0	2	0	2	0	0	0	0	0	0	5	0	0	0	2	0	0	2	1	0	49.3	30.1	20.5
2.1.2(a)	2	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	86.3	5.5	8.2
2.1.2(b)	3	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86.3	4.1	9.6
2.1.3	5	3	5	5	5	3	5	3	5	5	5	5	2	2	2	5	4	3	5	3	3	3	0	3	4	3	3	3	5	5	3	5	0	4	0	4	5	5	6.8	41.1	52.1
2.1.4(a)	2	2	2	2	0	2	2	0	0	0	2	2	0	2	2	0	2	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	56.2	0	43.8
2.1.4(b)	2	0	2	2	2	0	2	0	0	0	2	2	0	2	2	0	2	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	46.6	0	53.4
2.1.5	3	3	3	3	0	3	0	3	0	0	0	0	0	0	3	3	0	0	3	0	0	3	3	0	0	3	3	0	0	0	0	3	1	0	0	2	3	3	45.2	2.7	52.1
2.2.1(a)	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	0	2	2	2	5.5	0	94.5
2.2.1(b)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	1	0	0	1	1	1	15.1	0	84.9
2.2.2(a)	3	2	3	2	2	0	3	0	2	3	3	2	3	2	3	0	0	0	0	0	0	2	0	3	2	1	1	0	0	0	0	0	3	0	2	2	2	3	24.7	34.2	41.1
2.2.2(b)i	2	0	0	0	0	0	2	2	2	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	61.6	1.4	37
2.2.2(b)ii	2	2	2	0	0	0	2	2	2	2	2	0	0	0	0	0	2	0	0	1	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	1	1	2	49.3	1.4	49.3
2.2.3(a)	3	0	1	0	1	0	1	3	1	1	1	1	1	0	0	0	0	0	1	0	1	1	1	0	1	0	1	1	0	0	1	0	1	1	0	1	1	1	30.1	57.5	12.3
2.2.3(b)	4	2	2	4	0	0	2	2	0	2	2	2	0	4	0	0	0	0	1	0	2	1	2	0	0	4	0	0	0	4	0	0	0	0	2	2	2	2	38.4	45.2	16.4
3.1.1	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	0	2	0	2	2	2	0	2	2	2	0	2	2	0	0	2	2	2	2	9.6	2.7	87.7
3.1.2	2	0	2	2	2	0	0	2	0	2	2	2	2	2	2	2	2	0	2	0	0	0	0	2	2	0	0	0	2	0	0	2	0	0	2	1	2	2	37	2.7	60.3
3.1.3	3	0	0	3	3	3	0	3	0	3	0	1	1	3	0	0	3	3	2	2	1	0	3	2	1	1	0	1	1	1	1	1	0	1	0	2	1	3	24.7	43.8	31.5
3.2.1	3	3	0	3	0	3	0	1	1	3	3	3	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	1	2	3	3	34.2	15.1	50.7
3.2.2	4	2	1	0	4	2	4	2	2	4	1	1	2	1	3	1	1	2	2	1	4	1	2	2	1	0	4	1	2	1	2	2	0	1	0	2	2	2	12.3	78.1	9.6
3.2.3(a)	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	87.7	0	12.3
3.2.3(b)	5	0	2	0	5	4	0	1	0	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	60.3	32.9	6.8
3.3.1	2	2	0	2	0	0	2	2	2	2	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	2	2	0	0	0	2	0	1	2	2	35.6	1.4	63
3.3.2	4	4	0	0	0	0	1	1	3	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2	1	0	45.2	26	28.8
3.3.3	4	4	2	2	0	4	0	2	2	0	2	2	0	0	2	2	0	2	2	2	4	2	0	0	0	0	0	0	0	0	2	4	0	0	0	2	2	4	31.5	32.9	35.6
4.1.1	2	0	0	0	0	2	0	0	0	0	0	0	2	0	2	2	2	0	0	2	2	2	2	2	0	0	2	2	0	0	0	0	0	0	2	1	0	0	63	0	37
4.1.2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95.9	0	4.1
4.1.3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94.5	0	5.5
4.1.4(a)	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	1	0	0	65.8	11	23.3
4.1.4(b)	3	0	2	1	0	3	3	0	3	0	3	3	0	1	0	3	1	0	3	3	3	3	3	0	3	0	0	1	3	3	3	0	3	1	0	2	3	3	24.7	19.2	56.2
4.1.4(c)	4	0	2	2	4	4	0	0	2	0	0	4	4	2	0	4	0	0	4	0	0	0	0	0	2	0	0	0	0	2	2	0	2	0	0	2	2	0	39.7	21.9	38.4
4.1.5	3	0	3	3	3	3	3	0	3	0	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	1	3	3	0	1	3	3	1	2	3	3	15.1	6.8	78.1
4.2.1	5	0	0	1	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	58.9	41.1	0
4.2.2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90.4	8.2	1.4
4.2.3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	0	2	2	2	6.8	0	93.2
4.2.4	4	0	0	2	2	0	0	0	2	0	0	0	2	0	0	0	2	0	0	4	4	0	2	2	2	4	0	0	0	0	0	0	0	0	0	2	2	0	43.8	32.9	23.3
5.1.1	2	2	0	2	2	0	2	2	2	2	0	2	2	2	2	0	2	2	2	0	0	0	0	2	0	0	0	2	2	2	0	0	0	0	0	2	2	2	21.9	0	78.1
5.1.2	3	3	0	3	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	65.8	1.4	32.9
5.1.3	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	97.3	2.7	0
5.1.4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	2	2	0	2	0	0	0	0	0	0	0	0	0	1	0	0	74	8.2	17.8
5.2	5	0	2	0	2	0	0	2	0	0	2	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	64.4	34.2	1.4
5.3	3	0	3	0	0	0	0	1	0	0	0	3	3	3	3	0	0	2	0	0	0	1	0	0	1	1	1	3	0	0	2	0	0	0	1	1	0	0	52.1	15.1	32.9
TOTALS	150	66	66	60	60	59	59	57	57	54	53	51	49	49	49	48	47	45	43	40	40	40	40	39	38	38	37	36	35	35	31	31	24	22	15	66	69	94			
%	100	44	44	40	40	39	39	38	38	36	35	34	33	33	33	32	31	30	29	27	27	27	27	26	25	25	25	24	23	23	21	21	16	15	10						