A COMPARISON BETWEEN THE CONTEXTS GRADE 10 LEARNERS PREFER FOR MATHEMATICAL LITERACY AND THOSE REFLECTED IN THE TIMSS SURVEY.

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KEYWORDS

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ABSTRACT

This study focuses on the contexts grade 10 learners prefer to deal with in mathematical literacy. These preferred contexts of the learners were then compared with the contextual situations found in the Third International Mathematics and Science Study (TIMSS). The most important findings of this study are that grade ten learners from low socio-economic environments regard mathematics and mathematicians' practices as the most favoured items. The extra-mathematical clusters that they prefer are the technology and health cluster. TIMSS designers favoured the financial cluster flavored with youth cultural elements and technological devices that the youth are associated with. What learners find relevant or interesting may differ from what designers of tests may perceive to be relevant or vice versa.

DECLARATION

I declare that *A comparison between the contexts Grade 10 learners prefer for Mathematical Literacy and those reflected in the TIMSS survey* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Charles John Snyders May 2006

Signed:...

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Chapter 1
Introduction

1.1 Purpose

This study focuses on the contexts grade 10 learners prefer to deal with in mathematical literacy. These preferred contexts of the learners are then compared with the contextual situations found in the Third International Mathematics and Science Study (TIMSS, 1995).

1.2 Motivation

Many studies have been done on learner interest in mathematics, but this study focuses on the contextual situations learners would find interesting to deal with in mathematics or mathematical literacy.

There is a worldwide call for the relevance of mathematics in a technology-driven society where human beings are more and more exposed to quantitative situations. There is a huge need for people to apply mathematical knowledge and skills to real life or to mathematise contextual situations. Relevance in this case refers to a kind of mathematics that empowers the general public to cope in this kind of society. Mathematical literacy which deals primarily with contexts could be used to satisfy that need. The notion of relevance of mathematics is then closely linked to mathematical literacy. Obviously, what comes to the fore is which real life situations are relevant for whom and for what reasons.

The quest to improve mathematics in terms of its content and utilising current contexts to make it more user-friendly and relevant is constantly high on the agenda of education authorities. Thus, it is imperative to reflect upon the general aims of mathematics education as stated by Niss (1996). He claims that a vast majority of countries pursue the following aims:

Exterior aims:

- to provide substantial mathematics education for all, and not only to the future members of society's intellectual or social elite, while emphasizing that mathematical competence, in some form or other, is available to everyone;
- To provide opportunities for differentiated teaching and learning to the individual learner, while paying attention to his or her personal background;
- To emphasize participation and co-operation amongst learners in dealing with collective tasks related to mathematics;
- To assess pupils' mathematical potential, achievement and performance in ways which are in accordance with the higher order goals of mathematics teaching and learning.

Interior aims:

- To focus on the needs and interests of the individual learner, in order to prepare him or her for active participation in all aspects of private and social life, including active and concerned citizenship in a democratic society;
- To develop pupils' personalities by engendering or enriching self-respect and self-confidence, independent and autonomous thinking (including logical thinking), the development of explorative and research attitudes, linguistic capacities, aesthetic experience and pleasure, etc.;
- To emphasize pupils' mathematical activity rather than their passive acquisition of knowledge;
- To emphasize mathematical processes (such as exploration, investigation, conjecturing, problem posing/formulation/solving, representing, proving, modelling) and not only products (concepts, results, methods, skills);

- To foster mathematical thinking and creativity, while emphasizing that mathematics is a living subject resulting from human activity and from continuing efforts of humankind over five millennia;
- to enable pupils to identify, pose, formulate and solve mathematical problems, whether pure or applied, whether closed or open;
- to enable pupils to understand and appreciate the special nature of mathematics;
- to enable pupils to apply mathematics to extra-mathematical situations by means of models or modelling;
- to enable learners to critically analyse and judge uses of mathematics (their own as well as others) in extra-mathematical contexts;
- to provide students with an impression of and insight into the role of mathematics in society and culture;
- to make pupils familiar with current information technology in relation to mathematics.

(Niss, 1996: 32 - 33)

If one analyses these aims carefully, one would notice that there is great emphasis to move towards a context-driven and socially relevant curriculum in mathematics which promotes individuals who could function as critical and participating citizens. If one looks closely at the aims of the subjects, mathematics and mathematical literacy in South Africa, nearly all of the above- mentioned aims are embedded in the Revised National Curriculum Statement (RNCS) and National Curriculum Statement (NCS) (2002, 2003a;b). Since it is not the focus of this section to engage with all the aims per se, the focus will only be on those aims relevant to this study as required whilst the dissertation unfolds.

Locally, in South Africa, mathematics or mathematical literacy is now compulsory up to Grade 12, the final year of schooling. In other words, it has been legislated that as from 2006 every learner will complete his/her school career by studying either mathematics or mathematical literacy, as one of four compulsory subjects in the final three years of schooling - the Further Education and Training (FET) band. A broad discussion of the Further Education and Training band (Grade 10 – 12) will follow.

This requirement, that all learners are compelled either to do mathematics or mathematical literacy, coincides with the very first aim highlighted by Niss (1996). He also stated that there should be a focus on the needs and interests of learners in order to prepare them for active participation in all aspects of private social life, including active and concerned citizenship in a democratic society. A question that arises is what are the interest of learners and how can such choices be included in their school experiences?

In my experience as a teacher, I have found that if learners are not interested in an aspect of a subject, they find it very difficult to identify with and make sense of it. Whenever mathematics is taught only as a set of rules, facts, skills or algorithms with little understanding of the underlying concepts, most students have difficulties with the subject. Conceptual understanding should also be promoted by educational authorities.

De Lange (1996, 87) described the following scenario that played off in the Netherlands where context-driven school mathematics has been followed for some time:

> In the Netherlands a group was formed during the seventies to battle against the innovation called Realistic Mathematics Education. For a short period, it had considerable success in pointing out that basic skills were threatened. A report in the Netherlands seems to indicate that at the primary school level the 'new' students perform equally well in basic skills as the students in the old curriculum, and that they outperform students in the old curriculum in the field of problem solving.

One of the characteristics of Realistic Mathematics Education is that the teaching of mathematics is embedded in real life situations and learners are encouraged to use different approaches as well as their own to solve mathematical problems. In other words, the teaching of basic mathematical skills was not given extensive attention. In such a case learners could relate to these real life situations and make meaning and problem solving less challenging.

One of the key features of curriculum change in South Africa with regard to the introduction of mathematical literacy, which will be a new subject in the FET-band, is that it will be to a large extent context-driven. Obviously, no claims can be made that dealing with contexts in mathematical literacy will contribute towards the alleviation of the difficulties learners experience with mathematics. On the contrary, it might introduce a different set of difficulties.

In almost all cases the designers (policy makers, curriculum designers, educational authorities, text book writers, etc.) of mathematical learning resources are adults and use contextual situations which they perceived to be of use for the learners' individual, societal, current and "futuristic' needs. Of course, there is nothing wrong with such a process, since the expertise of adults place them in a position to determine the prospective demands. It could be of value to the designers of learning materials, examinations and tests to have this kind of information which can give them an idea what the preferences of these learners are with regard to contextual situations. This study, therefore, focuses on the contexts which learners will find interesting to deal with in the pursuit to embrace the relevance of Mathematics.

The following extract emphasizes that no matter the level of mathematical skills a country displays, there are aspects that need to be emphasized. One of them is the aspect of interesting lessons.

Nakagomi (2000, 746-751) stated that:

> In the TIMSS, junior high school students in Japan were placed third among participating countries, yet 47 percent of the students reported that they dislike mathematics. That percent is much higher than the international average of 32 percent who claimed to dislike the subject. Even though comparative scores are very good in Japan, why do many students dislike mathematics? One reason he asserts could be that mathematics classes may not be taught in an interesting way. A second reason may involve students who have been unable to continue getting good grades. They may have fallen behind, and Japanese students are negative about their own grades dropping. As a junior high school mathematics teacher in a public school, I speculate that an additional problem may be students' inability to adequately express their opinions. Perhaps students are passive because lessons emphasize solution methods and recall of knowledge, whereas students are rarely asked to put their knowledge to use in creative ways.

Although this study focuses on the contexts learners are interested in for use in mathematical literacy, it is worthwhile to look at a country whose results in international tests is one of the best such as Japan. There is relatively large percentage of students that dislike mathematics. But, the concept "interesting" appears as one aspect that is strongly needed as a catalyst to inspire learners to pursue with mathematics or mathematical literacy. The other aspect that one should take note of is the fact that Nakagomi stated that learners are rarely asked to put their knowledge to use in creative ways. The question arises within what framework or area should it be done? One of the areas could be contextual situations. Therefore this study is geared to explore one of the aspects that can enhance this notion of 'interesting' contexts from the learners' perspective and investigate how such contexts are reflected in a large-scale international comparative test such as TIMSS.

Choike (2000) shared his teaching strategies and recommended that teachers should mould lessons, whenever it is possible, around the interests of individual learners. He mentioned that the following situation actually occurred in a ninth grade algebra class in a high school in an eastern suburb inner city in the United States. Students in this ninth grade class were presented with the following performance-based guided-exploration task.

> A farmer had 24 yards of fencing. What are the dimensions of a rectangular pen that gives his sheep maximum grazing area? All students were equipped with the necessary resources. Students were enthusiastically involved in this problem and were busily drawing sample rectangular pens on grid paper and noticing that the pens could be constructed in many ways. All students were engaged, that is, except for one young lady who had quietly detached herself from her group. She preferred, instead, to focus on her grooming. She fluffed her hair and checked her eye shadow and her nail polish. When asked why she was not interested in the problem, she commented respectfully, yet honestly, that she could not care less about sheep in a pen.
> The teacher discovered that the student liked flowers, in particular red roses. Homing in on this volunteered interest, the teacher restated the problem for Maria as follows:
>
> Maria has 24 yards of fencing, which she can use to make a rectangular garden for growing red roses. Each rosebush needs space to grow. A one-yard-one-yard square gives the rosebush sufficient growing room. What dimensions will allow her to plant the maximum number of rosebushes in this rectangular garden?
>
> With this new setting, tailored to Maria's interest in roses, Maria smiled delightedly at the teacher and became involved in the activity.
>
> (Choike, 2000: 560)

This extract confirms that contexts that interest learners, increase involvement or engagement into the problem and raise the chances to make meaning and mathematical problem solving possible. This extract points directly to what this study wants to achieve.

Clarke and Helme (1996) distinguish between figurative context and interactive context. The figurative context refers to the real scenario the task is embedded in and the interactive context describes the conditions the task is encountered by a student. Stillman (1998) wanted to explore the connection between students' performance on application tasks and their engagement with the figurative context of the task. Her finding was that the data showed that there was a link but that further factors must be considered in order to explain all the results obtained.

This study focuses on the figurative context, but equivalent terms such as context or contextual situations are used. It wants to ascertain what "figurative" contexts grade ten learners are interested to deal with in mathematical literacy. The interactive context will not be covered in this study.

Changes in society, driven by societal needs will of course have a major influence on the contextual situations of mathematical literacy, which in turn ought to be a dynamic subject that is constantly under scrutiny with regard to contexts. This will also apply to the interest of the learners in different contexts.

1.3 Research Question

This study focuses on what the contexts are that are favoured by the TIMSS mathematical literacy instrument and how they compare with learners' context interests as manifested by the Relevance of School Mathematics Education (ROSME) instrument for grade 10 learners. The study reported here is broadly situated in the realm of the school setting where learners completed questionnaires which reflected different contextual situations such as political, financial, agricultural, sports, youth culture, health and transport issues as contexts for mathematics or mathematical literacy. These contexts were pre-determined but provision was made for learners to add contexts they prefer.

1.4 Conclusion

In this chapter I have provided a rationale to pursue with the focus question: What are grade 10 learners' contextual preferences and how do they compare with the contexts favoured by TIMSS? In Chapter 2, the literature will be reviewed and Chapter 3 will deal with Research Methodology. Chapter 4 focuses on the findings from the analysis of the data and Chapter 5 entails my conclusion.

Chapter 2

Literature Review

2.1 Introduction

In this chapter the idea of relevance will be discussed. To enhance this issue of relevance, it will be pursued through mathematical literacy which deals primarily with contexts. Hence, mathematical modelling will come to the fore. The relevant literature will be explored to clarify and link these concepts with each other.

2.2 Relevance of Mathematics

The debate about and search for the relevance of mathematics is prominent in many countries and has been pursued over a long period of time. This will always be the case since mathematics is one of the subjects that is a key and crucial factor for development in a vast majority of sectors in society. Ernest (1996) posited that mathematics is generally agreed to fulfil social needs, to provide the skills relevant for everyday life and work in industrial and developing societies, as well as the basis for further study in mathematics, science and technology. The selection of content and the mode of teaching in mathematics is often claimed to be driven by relevance to these needs. This is widely agreed upon.

Ernest (1996) stated that what is often overlooked, perhaps less so today, is that 'relevance' and 'need' are not neutral objective judgements, but are based on the perspective of the judge, and the aims at which the judgement is directed. Any such judgement, however much integrity is involved, is determined by what the maker of judgements considers to be appropriate or right according to Ernst (1996). It must be mentioned that if the judgement is based on the perspective of the judge it is no longer objective. At this stage there is already an indication that the 'relevance' and 'need' will implicate different accentuations for different people.

The South African concise Oxford Dictionary (2002) defines relevance as: "Closely connected or appropriate to the matter in hand." On the other hand relevance could also embrace the whole idea of interest. Relevance or interest could be pointing towards relevant to the situation; and of interest or relevance to the participants, roleplayers or stakeholders. In this study I will frequently use the term 'interest' as a notion that also embraces the whole concept of relevance.

Relevance could relate to the fact that in every sphere of society where human beings are involved, quantitative, numerical or mathematical interpretations are always part of those real life situations. It is expected that people should make sense of these mathematically-based arguments or situations. An alarming number of South Africans have low levels of numeracy or mathematical literacy according to numerous studies like the TIMSS report by Howie and Hughes (1998). This is therefore, one of the reasons why mathematical literacy will be introduced as a compulsory subject to those learners who will not take formal mathematics in the Further Education and Training band, as a subject in South Africa.

On the 4th of June 2005 I did a Google Advanced Search on the issue regarding learners' interest in the contextual situations through which mathematics or mathematical literacy could be approached. Unfortunately, I did not get any results. To investigate and explore this notion the following quotes were used: "learners' preference of contexts to do mathematics"; "learners' interest in the different contextual situations in mathematics" and "learners' interest in the contexts of mathematics". This advanced search was repeated thrice, but did not yield any results. Thus, very little research has been done in this area of study. To focus on contextual situations I will pursue this issue through mathematical literacy.

2.3 Mathematical Literacy

The term literacy broadly refers to the use of human language. When human beings are able to read, write and listen but also to use a language in a variety of situations at hand, they are regarded as literate. In this regard Romberg (2001, 5) asserts that:

> A person to be literate in a language implies that he or she knows many of the design resources of the language and is able to use those resources for several different social functions. When analogously considering mathematics as a language implies that students not only must learn the concepts and procedures of mathematics (its design features), but they must learn to use such ideas to solve non-routine problems and learn to mathematise in a variety of situations (its social functions).

This notion can be regarded as mathematical literacy.

Generally to be literate means to be competent, to have the appropriate skills to cope and make judgments pertaining to the issue at hand. In my opinion, the specialists are those who possess specialist mathematical knowledge, design and construct models and devices. The users (general public) should be at ease to understand and use those models or devices to cope, criticize, and even redesign them to use it to their benefit. In that sense one can describe such a person as literate or not.

In many cases quantitative literacy, numeracy and mathematical literacy are regarded as equivalent terms but others try to discriminate between them to fulfil a certain purpose.

In the South African context, a clear distinction is made between numeracy and mathematical literacy. This distinction might have arisen as result of the National Qualifications

Framework (NQF) against which all qualifications are registered in South Africa, because in the General Education and Training Band (GET) (grades R – 9) a mixture of numeracy and mathematics is done.

Table 2.1 of the National Qualification Framework will help with discussing this issue with regards to the place of mathematical literacy and numeracy in the South African context.

In the Further Education and Training Band (FET), there is a clear distinction between mathematics and mathematical literacy, as separate subjects.

In The National Curriculum Statement (Department of Education: 2003b, 7) Mathematics is defined as:

> Mathematics enables creative and logical reasoning about problems in the physical and social world and in the context of Mathematics itself. It is a distinctly human activity practised by all cultures. Knowledge in the mathematical sciences is constructed through the establishment of descriptive, numerical and symbolic relationships. Mathematics is based on observing patterns; with rigorous logical thinking, this leads to theories of abstract relations. Mathematical problem solving enables us to understand the world and make use of that understanding in our daily lives. Mathematics is developed and contested over time through both language and symbols by social interaction and is thus open to change.

On the other hand, mathematical literacy is defined in the National Curriculum Statements (2003a, 9) as:

> Mathematical Literacy provides learners with an awareness and understanding of the role that mathematics has 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.

Table 2.1: National Qualification Framework (NQF)

NQF: National Qualification Framework				
NQF Level	**Higher Education and Training** (HET)			
8				
7				
6				
5				
	School Grades			
4	12- Exit Grade in Schools	Further Education and Training (FET) Further Education and Training Certificate-Grade 12 (FETC)		
3	11			
2	10			
1	9-Exit Grade in Schools	General Education and Training or Senior Phase (GET) General Education and Training or Senior Phase Certificate-Grade 9	ABET Level 4	Adult Basic Education and Training ABET-Equivalent to the Grades in schools
	8			
	7			
	6		ABET Level 3	
	5			
	4			
	3			
	2		ABET Level 1 & 2	
	1			
	R			

Differences that are evident from these two definitions are that in mathematical literacy the usage of mathematics in the real world is being emphasized, whereas in mathematics the very context should be mathematical in nature. The mathematical structures and objects for mathematics is then of utmost importance, although the physical and the social world could be contextual situations. The definition of mathematical literacy is also geared towards sensitizing individuals about the role and usage of mathematics whereas a deeper understanding of the underlying theory of mathematics and also to use it in real world situations is envisaged in mathematics. There will be common aspects about mathematics and mathematical literacy, since both disciplines have to do with mathematics and are also applications-driven, especially where the mathematics could go beyond mathematics as a context. In fact, it is not easy to demarcate between the two since they are closely linked to each other. Mathematical literacy in turn deals primarily with real life situations.

To have a closer look at the difference between mathematics and mathematical literacy is to compare the learning outcomes of each discipline as been described in the respective curriculum statements (2003a;b) as displayed in table 2.2.

Learning outcome 1 (Number and Operations in Context) of mathematical literacy noticeably underlines the usage or application of numbers within a contextual situation (extra-mathematical), whereas that for mathematics is rooted in intra-mathematical situation (for example description of numbers) but could also be applied in the extra-mathematical situations.

Learning outcome 2 (Functional Relationships) of mathematical literacy states that knowledge of functional relationships should be based on problems situated in real life and simulated contexts. In other words functional relationships should be contextualised. In mathematics, learning outcome 2 (Functions and Algebra) a wide

Table 2.2: Learning Outcomes of Mathematical Literacy and Mathematics

MATHEMATICAL LITERACY	MATHEMATICS
LEARNING OUTCOME 1 **Number and Operations in Context:** The learner is able to use knowledge of numbers and their relationships to investigate a range of different contexts which include financial aspects of personal, business and national issues.	**LEARNING OUTCOME 1** **Number and number Relationships:** When solving problems, the learner is able to recognise, describe, represent and work confidently with numbers and their relationships to estimate, calculate and check solutions.
LEARNING OUTCOME 2 **Functional Relationships:** The learner is able to recognise, interpret, describe and represent various functional relationships to solve problems in real and simulated contexts.	**LEARNING OUTCOME 2** **Functions and Algebra:** The learner is able to investigate, analyse, describe and represent a wide range of functions and solve related problems.
LEARNING OUTCOME 3 **Space, Shape and Measurement:** The learner is able to measure using appropriate instruments, to estimate and calculate physical quantities, and to interpret, describe and represent properties of and relationships between 2-dimensional shapes and 3-dimensional objects in a variety of orientations and positions.	**LEARNING OUTCOME 3** **Space, Shape and Measurement:** The learner is able to describe, represent, analyse and explain properties of shapes in 2-dimensional and 3-dimensional space with justification.
LEARNING OUTCOME 4 **Data Handling:** The learner is able to collect, summarise, display and analyse data and to apply knowledge of statistics and probability to communicate, justify, predict and critically interrogate findings and draw conclusions.	**LEARNING OUTCOME 4** **Data Handling and Probability:** The learner is able to collect, organise, analyse and interpret data to establish statistical and probability models to solve related problems

range of functions should be studied intra-mathematically, but as numbers which are related in some way, them could also be studied in extra-mathematical situations.

Just by analysing these two learning outcomes it is evident that mathematical literacy is to a large extent context driven, whilst the teaching and learning of mathematics could be done in intra- and extra-mathematical situations. Although the learning outcomes for mathematics and mathematical literacy are more or less the same, it is clear that the focus in some cases overlaps but the difference points in the direction as indicated in the latter notion of mathematical literacy and mathematics.

The Department of Education (2002, 4) has also a Revised National Curriculum Statement for the GET-band and it is important to look at that definition of Mathematics which is:

> Mathematics is a human activity that involves observation, representing and investigating patterns and quantitative relationships in the physical and social phenomena and between mathematical objects themselves. Through this process, new mathematical ideas and insights are developed. Mathematics uses its own specialised language that involves symbols and notations to describe numerical, geometrical and graphical relationships. Mathematical ideas and concepts build on one another to create a coherent structure.
>
> Mathematics is a product of investigations by different cultures- a purposeful activity in the contexts of social, political and economical goals and constraints.

Although this definition of mathematics coincides with the definition of mathematics in the FET-band it also promotes mathematical literacy in general. The definition of the mathematics in the GET-band also emphasizes that mathematics should be seen as part of the real life situations, in the physical and social contexts.

In terms of the South African Qualification Authority's regulations, mathematics and mathematical literacy are fundamental subjects. This means that all learners in FET-schools will have to do either one of the two as previously explained.

On the other hand, in South Africa the term numeracy refers to the mathematics being taught at GET- band and largely at the Foundation and Intermediate Phases (Grades R – 6) as well as at ABET levels 1 & 2. Despite the official recognition of only mathematics (Grades R – 12) and mathematical literacy (Grades 10 – 12) some government departmental officials and politicians refer to mathematics in Grades R – 3 as numeracy as articulated by Dugmore (2005) and Pandor (2005). Numerous textbooks titles for example, Understanding Numeracy (2003) and Numeracy All Board (2003) contain also the term numeracy which points towards the mathematics in Grade R – 3.

Another term that comes to the fore is quantitative literacy. In a country like Canada the International Life Skills Survey (Policy Research Initiative, Statistics Canada, 2000) cited by Steen (2001) claims that quantitative literacy is quantitative situations arising in life and work. Steen (1997) also cited Porter, a historian who asserts that quantitative literacy involves understanding the role of numbers in the world and to critically analyze real issues. According to Steen (2001) quantitative literacy is concrete and contextual, dealing with contingent inferences drawn from specific facts about real objects or events. There is to great extent uniformity that the location, the source of quantitative literacy is real world situations.

The term real world is not easy to define and very complex in nature. Real world or everyday life is a scenario constituted by so many factors and influences, therefore it is multifaceted by nature. The "real situation" occurring in everyday life, the interplay of mathematics in that particular situation is influenced by an array of elements and vice versa.

Critical elements could range from values, religion, socio-economic issues, political and even historical influences. De Lange (1996, 56) pointed out that "in part we may consider the 'concrete real world' the world that comes across to children and students through mathematics in applications. But we must not forget that each child (and adult) already has an implicit definition of her or his own real world that may not be known to the outside world, including teachers and curriculum designers." This study wants to probe part of that "unknown real world" of the learners.

Mathematics is embedded in these complex real world situations. Quantitative data from real life is then called quantitative situations. Quantitative situations to a large extent reflect then in some or other way human involvement. This brings a social dimension towards quantitative literacy. It is then expected that humans are knowledgeable about these routine events loaded with quantitative data. The ability to deal with these quantitative situations, is regarded as quantitative literacy.

Steen (2001, 8-9) identifies the following elements that are characteristic of quantitative literacy:

- confidence in mathematics,
- cultural appreciation,
- interpreting data,
- logical thinking,
- making decisions,
- mathematics in context,
- number sense,
- practical skills,
- prerequisite knowledge,
- symbol sense.

Another issue is the mathematising of non-mathematical situations and which by implication is quantified. Thus, the notion of mathematical modelling comes to the fore. A broad discussion on mathematical modelling will follow later.

Evans (2000) in turn defines numeracy as "the ability to process, interpret and communicate numerical, quantitative, spatial, statistical, even mathematical information in ways that are appropriate for a variety of contexts and that will enable a typical member of the culture or subculture to participate effectively in activities that they value."

Surely there are different meanings attached towards numeracy, some coinciding with the notion of mathematical literacy. The South African perspective on numeracy refers more towards the numerical skills and aspects related to the Foundation Phase. Quantitative literacy goes further and aims to apply these "numerical" and mathematical skills to real life contexts. Real life situations also provide a base to be treated mathematically. By mathematising real life situations, mathematical literacy is introduced. Hence, to avoid confusion I shall from now on use mathematical literacy as the term that will embrace numeracy, as well as quantitative literacy. The Organisation for Economic Co-operation and Development (OECD) (2003) defines mathematical literacy for the Programme for International Student Assessment (PISA) as:

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

Mathematical literacy is variously defined but across these variations there is a great deal of overlapping as illustrated by the above definitions or descriptions of what mathematical literacy entails. Both definitions, the one of the Education Department and that of OECD refer to the fact that an individual should have the ability to understand the role of mathematics in the world, in real life or everyday situations. The essential outcome of mathematical literacy is to create critical and reflective citizens in terms of the use of mathematics as well as related issues.

According to the definition of the Education Department (2003a) the emphasis is also on the application of mathematics in real life situations. These life-related applications differ from the normal "word problems". There should be an awareness in application of mathematics to real life situations that the 'realistic' situations could become 'unrealistic'.

An item taken from the 1992 pilot national curriculum in England for mathematics test for 14 year olds, cited by Cooper (1992), but taken further by Wiliam (1997, 4):

Table 2.3 : Realistic Problem Solving

This is the sign in a lift at an office block: This lift can carry up to 14 people. In the morning rush, 269 people want to go up in this lift. How many times must it go up?

> Since the test was intended for 14 year olds and they were allowed to use calculators most students had little difficulty in realizing that the solutions to the item involved was dividing 269 by 14. Only 20, by rounding off were regarded as a 'realistic' response, whilst any non-integral answers were regarded as 'non-realistic'. However, as Cooper pointed out arriving at the 'correct' answer of 20 requires many assumptions (eg. That the lift is full apart from the last trip, that no one gets fed up and uses the stairs, that the restriction is based strictly on number and not also on mass and volume, so that for example, none of the people using the lift are wheel chair users).

In other words the designers should be alert not to force applications, but to come up with realistic situations and problems to solve; otherwise it could lead to these kinds of distorted examples of real life applications. Using mathematics to solve "real" world problems is often called applying mathematics, and a "real" world situation which can be tackled by means of mathematics is called an application of mathematics.

Romberg (2001, 5) also implicates the application of mathematics by stating that "the emphasis is on mathematical knowledge put into functional use in a multitude of different situations and contexts in varied, reflective and insight-based ways. For this to be possible a great deal of fundamental knowledge and skills are needed."

A description of where mathematical literacy could be situated is presented by the ICMI Study 14 (2002, 6):

> The term "application", on the one hand, focuses on the opposite direction mathematics → reality and, on the other hand and more generally, emphasizes the objects involved – in particular those parts of the "real" world which are accessible to a mathematical treatment and to which corresponding mathematical models exist. The term modelling, on the one hand, focuses on the direction, reality → mathematics and, on the other hand and more generally, emphasizes the processes involved. These descriptions of application and modelling are widely accepted.

Terms that are not so prominent at this stage is mathemacy (Skovsmose is cited by Ernest, 1996) which is regarded as critical mathematical literacy and matheracy (D' Ambosio,1985) which refers to cultural and indigenous knowledge of mathematics. Both concepts are perceived as an approach to mathematical literacy.

Mathematical literacy for cultural identity is prevalent in the developing countries, where there is a great discrepancy between the mathematics the pupils use in their everyday lives and that which they use to solve everyday problems. This approach serves as argument to give this informal mathematics a more important place in the curriculum. This informal mathematics can be seen as a form of mathematical literacy, and has been referred to as 'ethnomathematics'. D'Ambrosio (1985) warns that the "spontaneous matheracy" that is common among the unschooled is often eliminated by the "learned matheracy" of the school. He also stated that the distinct formal approaches to mathematics presented in schools create a "psychological blockage" between the different modes of mathematical thought that on the one hand degrades the value of that which is "spontaneous" while at the same time it impedes the acquisition of that which would be "learned" in school. D'Ambrosio asserted that the increasing technological presence in the Third World countries demands improved mathematical competence, but spontaneous abilities are "downgraded, repressed and forgotten". He was led to the conclusion that the student becomes alienated from his reality, and thus the possibility for creativity through reflection and action on that reality is severely curtailed. D'Ambrosio is arguing for an approach to involve the informal and spontaneous matheracy and the most appropriate way is through contextual situations that they can identify with.

Jablonka (2003) sees mathematical literacy for social change from a critical pedagogic perspective, in other words mathematical literacy is the capacity to view reality differently and change it. Mathematical literacy needs to lead primarily to critical citizens with regard to socially and politically meaningful issues. This approach strongly criticises school mathematics, which only leads to continued inequality in knowledge, social class and sex.

Skovsmose as cited by Ernest (1996) also argues from that viewpoint that the goal of critical mathematical literacy is the empowerment of learners both as individuals and as citizens-in-society. Skovsmose distinguishes three competencies which together compose critical mathematical literacy, which he terms as mathemacy. These are mathematical competence (mathematical knowledge and skills at all levels), technological competence (technology knowledge and know-how, especially in the application of mathematics) and reflective knowing. Mathemacy can be regarded as critical mathematical literacy.

The common factor of all these approaches is that they are evident in real life, hence providing rich contextual situations, extra- and intra-mathematical, from which mathematical literacy can emerge. However, it is widely accepted that we want to prepare citizens (learners) for their future. "We" certainly here refers broadly speaking to the adults. In other words, the adults are in a responsible position to determine what the learner's future needs are by choosing relevant contexts to fulfil those needs. These contexts are synonymous with concepts like real life situations or extra-mathematical reality domain.

I regard mathematical literacy as the term that embraces quantitative literacy, numeracy, matheracy and mathemacy. In this study I shall use them in such a way that quantitative literacy and numeracy supports the build up towards mathematical literacy that will be the term predominantly used which in turn would also imply quantitative literacy, numeracy, matheracy and mathemacy.

2.4 Mathematical Modelling

Since mathematical literacy is also largely about using mathematics to deal with extra-mathematical situations, it is primarily about mathematical modelling which prioritises contexts. Mathematical modelling is a process with the objective of developing mathematical representations for situations from outside of mathematics. Although mathematical modelling shares characteristics with problem solving situations, it is distinctly different. Frequently, in a mathematical modelling situation, a phenomenon that is seemingly non-mathematical must be modelled in mathematics. This may be an event in the realm of politics, such as predicting election results; of economics, such as finding the long-term behaviour of oil prices; or even of ecology, such as predicting the future growth patterns of a forest. These situations can be regarded as quantitative situations, as labeled in the previous discussion on mathematical literacy. Important factors must be discerned, relationships must be determined, and these relationships must be mathematically interpreted. The mathematical interpretations of relationships allow for an analysis of the phenomenon so that conclusions (solutions) can be found. Thus, mathematical modelling is a systematic process that draws on many skills and employs the higher cognitive activities of interpretation, analysis and synthesis.

There are three domains involved in mathematical model making. These are the extra-mathematical reality, the consensus-generated reality domain and the intra-mathematical domains. The characteristics of these domains are reflected in figure 2.1 as outlined by Julie (2004, 35).

EXTRA-MATHEMATICAL REALITY DOMAIN	**CONSENSUS – GENERATED REALITY DOMAIN**	**INTRA-MATHEMATICAL DOMAIN**
Issues of a technical, physical, financial, social, political, environmental and so forth nature are at stake. Issues are complex and under a variety of influencing factors.	Issues are stripped of some influencing factors. Consensus is reached based on purposes and interests.	Mathematical procedures and ideas are developed and used. Mathematical conclusions are reached.

Figure 2.1: The translation of reality issues through different domains

These three processes of mathematical modelling are complementing each other to build up a more comprehensive description of a complex process regarding mathematical modelling. As Julie (2004) points out that the reality situation is transformed through consensus where interests and purposes are settled and the resulting mathematisation relates to this consensus-generated reality.

Mathematical devices to control, organise, predict and manipulate nature and social life has penetrated every part of reality. The applications of and the modelling in mathematics is one of the ways to reflect this inter-relationship between reality and mathematics. I am of the opinion that a great deal of emphasis should be placed on modelling in order to understand the effects of these mathematical models on our society. Since the intention is to create critical and reflective citizens towards issues in society, one of the most appropriate routes through which this outcome could be attained, is through mathematical modelling.

There are many representations that illustrate the processes involved in mathematical modelling, but Stillmans' (1998, 245) presentation in figure 2.2 brings to the fore the regulatory mechanisms through all the processes.

The representation (figure 2.2) of the mathematical modelling process is very simplistic because it ignores the complexity firstly of the extra-mathematical world and the complex mathematising process of that phenomenon which was discussed earlier according to Julie (2004).

The applications of and modelling in mathematics fall in the domain of basic human activity and it has the desire to describe things, to predict how things will develop and to prescribe what is needed in order for a particular result to be realised. It is useful to exemplify these purposes by looking at examples from the "real" world.

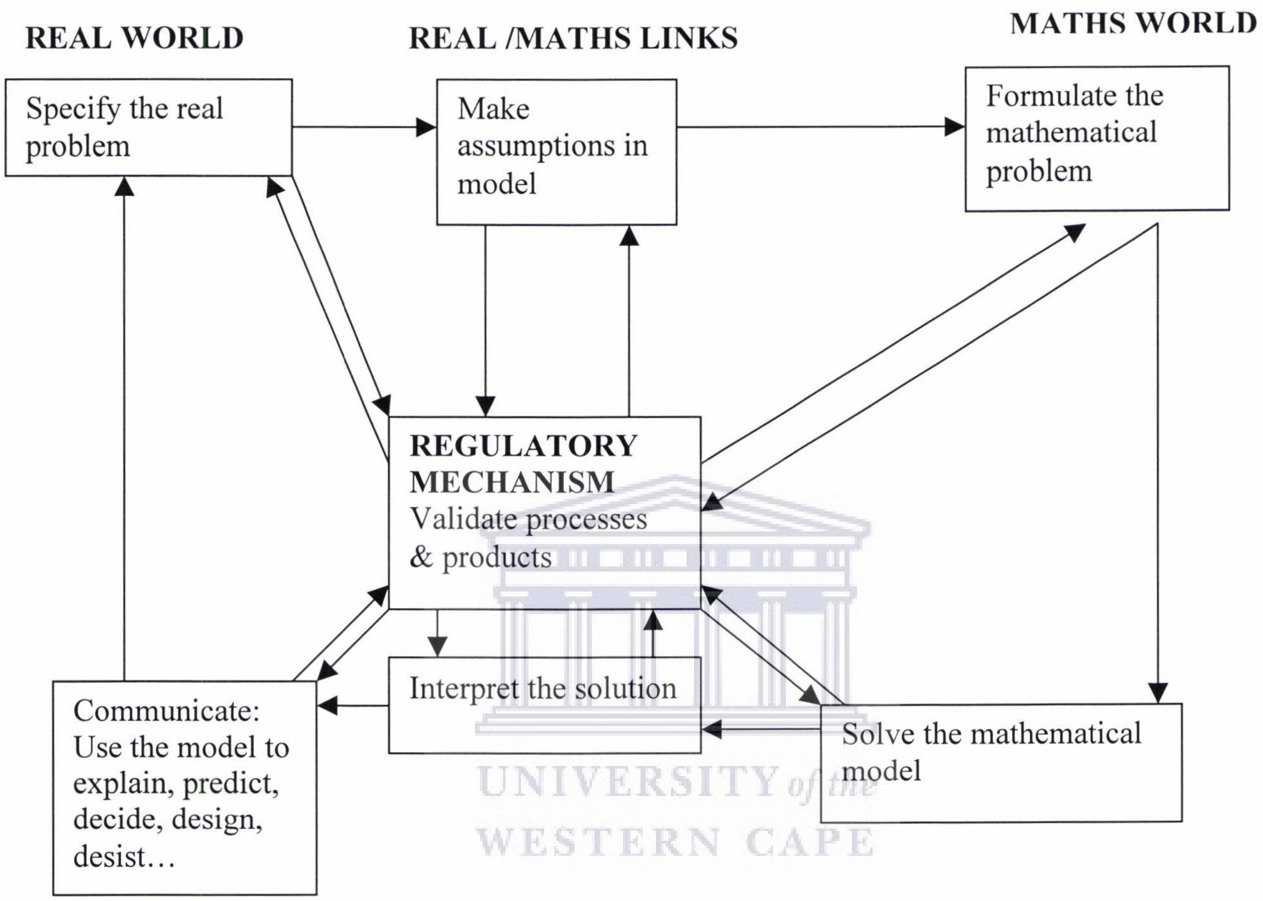


Figure 2.2: Stillmans' mathematical modelling presentation

Firstly, a mathematical model that will have a purpose to describe things could be illustrated by the following example:

The Lotto Jackpot in South Africa:

The chance of winning the Lotto Jackpot with just one ticket is one in nearly 14 million. (Mathematical Digest, July 2000). The jackpot is won by any ticket that bears the six numbers drawn at random from the numbers from 1 to 49.

The following formula involving probability can be used:

$$\binom{n}{r} = \frac{n!}{r!(n-r)!}$$

where r is referring to the number of objects and the set is n. In other words this model describes or informs what the chances will be to win the Lotto:

$$\frac{49!}{6! \times 43!}$$

= 13 983 816

1 : 13 938 816

The chance of winning the lotto is merely one out of fourteen million.

Indeed, "tata ma chance, tata ma millions!"

Secondly, a recently predicting model is the following extract from the Mathematical Digest of October 2003:

Happily ever after maths!

A mathematician has shown how to predict whether a marriage will be happy or not by using algebra. Professor James Murray, of the University of Washington, Seattle, USA, went public with his finding at a conference in Dundee, Scotland in August 2003.

With the help of a psychologist, Professor Murray conducted interviews with 700 couples. A couple's ability to communicate with each other on a range of subjects from sex to child-raising to money were assessed on an accepted psychological scoring system that gives positive points for good signals, such as a smile or an affectionate gesture, and negative points for bad signals such as rolling eyes or a sneer. The scores for the partners were then entered into two equations: one for the husband and one for the wife. These equations predict how successful a marriage will be. The couples were checked every two years and it was found that the model predicted which marriages would fail with almost complete accuracy.

Thirdly, a model can be of a prescriptive nature. With the new Medicine and Related Substances Act, a new prescribed model is at stake. The rationale behind this Act is supposed to make medicine more affordable to more people. The model generally entails the following:

During the first phase (2-26 May 2004) manufacturers, wholesalers and retailers must by law remove their discounts. In the meantime manufacturers must publish their single-exit price (SEP). The manufacturers' single-exit price must be similar to their lowest, best price after the bonuses, discounts and incentives which were offered before 2 May 2004.

In the second phase, after 26 May 2004 the manufacturers will have to list their lowest SEP and must include a fee for wholesalers and distributors. Scrutinising and fixing of prices should be completed at 2 August 2004.

In the third phase, from 2 August, Schedule 1 and 2 substances sold over the counter will be at the single-exit price, plus a dispensing fee of 16% capped at R16 where the single-exit price is more than R100. When sold on prescription Schedule 1 to 6 medications will be sold at the single exit price, plus a dispensing fee of 26% (mark up), capped at R26.

At one stage, there was a huge outcry about this model. The Minister of Health was taken to court by New Clicks and United South Africa Pharmacies (USAP) in two separate cases. To conclude, Gordin (2004) reported:

> Judge Louis Harms said that the state had not offered comprehensible evidence on how pricing mechanisms in the new regulations had been reached, but that the appellants (USAP) had offered the expert evidence of a highly qualified economist who had convincingly shown that "the fees earned in terms of the new regulations will not provide pharmacists in any of the sectors analysed with sufficient revenues to cover their operating costs…

A prescriptive model will always be open to criticism because different people or relevant role players have different interests and opinions regarding the outcomes and purposes of such a model as also reported in the Cape Times of 27 May 2004. It is beyond this assignment to go into the strengths and the weaknesses of this model.

This model illustrates the notion of seeking a consensus-generated reality domain which is sometimes a vigorous process. In many cases representations of the modelling process ignores this dynamic consensus seeking process.

These examples were deliberately chosen to highlight the specific purposes of using mathematical models. It should be mentioned that there are models that can have more then one purpose.

In the Mathematics Learning Programmes Guidelines (Department of Education, 2004b) it is stated that for "the purpose of developing learners' ability to work with mathematical models, it is useful to subdivide the area of mathematical modelling into":

a. **direct models**. These are models that can be directly generated from verbal representations. The model is an exact representation of the situation rather than an attempt to bring mathematics to bear on an imprecise real world problem. For example, functions created in linear programming problems are direct models.

b. **physical models**. These models are produced by using objects or diagrams to physically model a situation. At times this may require building objects to act as models thereby enabling us to produce a mathematical analysis of the situation. For example, using a jar of beans to physically model or represent the buffalo in the Kruger Transfrontier Park. Samples of 'buffalo' can then be drawn to test for disease or to calculate the entire population of buffalo in the park. In particular these models aid connections with content and processes evident in Learning Outcome 3 (Shape, space and Measurement).

c. **data models**. These models are generated as a line of best fit for a set of data. The model may not fit the data perfectly but is the best fit for the data. Data sets may be obtained from experiments conducted by the learners or it may be obtained from other sources (e.g. NGO's; Statistics South Africa; Government departments).

(Department of Education, 2004:84-85)

This is a direct quote from the source indicated. The physical models as exemplified are more simulation experiments and not really mathematical models per se. They are like teaching aids to assist the development of the models.

Mathematical literacy as a subset of applications and modelling, revolves around situations in the real world. According to De Lange (1993) the real world situation or problem is first explored intuitively, for the purpose of mathematising it. He also stated that the initial exploration, with a strong intuitive component, should lead to the development, discovery or (re)invention of mathematical concepts.

2.5 Third International Mathematics and Science Study (TIMSS)

The Third International Mathematics and Science Study (TIMSS) is regarded by Howie (1998) as the largest and most ambitious international study of mathematics and science achievement ever undertaken, with more than 500 000 school students in 41 countries being tested in mathematics and science at five different levels (equivalent to Grades 4, 5, 7, 8 and 12 in South Africa). In South Africa the decision was made to test Grade 7, 8 and 12 students only, due to financial constraints and the issue of the medium of instruction in the primary schools for the age group (Grade 4 and 5). In South Africa alone, a survey was conducted among 15 000 South African students from more than 400 primary and secondary schools in 1995.

The International Association for the Evaluation of Educational Achievement (IEA), based in the Netherlands, was responsible for undertaking TIMSS. The IEA, is an independent international grouping of national research institutions and government research agencies. Its primary purpose is to conduct large-scale comparative studies of educational achievement, with the aim of gaining a deeper understanding of the effects of policies and practices within and across systems of education.

About the key aspects of TIMSS, Howie (1998, 4) asserted the following:

> Achievement tests are of primary importance to the TIMSS study. These tests were developed collaboratively by the countries participating in the study and were subjected to extensive pilot studies and field trials. The questions were also reviewed by experts both in assessment and in science and mathematics curricula. About a third of the questions required the students to write their own answers, rather than select answers from multiple-choice options. Comparative studies in education gain more meaning when considered in relation to the educational context in which they are done. In TIMSS, data on a considerable number of contextual factors included in various

questionnaires were collected from principals, teachers, students, Education Department officials and curriculum experts.

South African students' overall scores were significantly lower than those students' in other countries, also the low level of general numeracy and scientific understanding was also evident. This was ascertained by students' responses to test items focusing on problems applied to the real world. Another major problem was the language difficulties. The majority of the South African students wrote the TIMSS tests in a language that was not their mother tongue. Since the mathematical literacy test paper comprised largely of word problems, it is possible that the language factor had a negative impact on achievement. When one refers to contextual situations through which mathematics and mathematical literacy could be fostered, the language issue should be taken into account. Since the language issue is not the focus of this study, I will not elaborate on or deal with this relevant and essential issue in this dissertation.

To assess the developments that had occurred since TIMSS was conducted in 1995, a repeat was launched in 1998/1999 labeled as TIMSS-R. Eight thousand learners in 200 schools participated in South Africa's study, which was conducted by the Human Sciences Research Council (HSRC).

It is worthwhile to look at the contextual situations that are embedded in the mathematical literacy items of such a comprehensive, internationally recognized study, like the TIMSS.

2.6 Conclusion

To adhere to the notion of relevance with regard to mathematical literacy it could be enhanced through contextual situations. If learners' interest in contexts embraces the notion of relevance their preferences should also be taken into consideration as far as contextual situations are concerned. It is also worthwhile to compare these preferences with the contexts the TIMSS-designers favoured since the test already went through the whole process as a research instrument as well as its status as a internationally recognized study.

In the following chapter the research methodology will be dealt with.

Chapter 3

Research Methodology

3.1 Introduction

To determine the contextual interests that learners prefer to deal with in mathematical literacy or mathematics a survey was used. A discussion will follow on the research instruments namely, the questionnaire that learners completed (see appendix 1) and the TIMSS Mathematical and Science Literacy test of 1995 (see appendix 4). The sampling and data collection processes, the data-coding procedures as well as the data analysis procedures will also be dealt with.

3.2 Research Instruments

3.2.1 Survey Research: ROSME Instrument

The determination of the preferences of learners was quantitative and the determination of the contexts present in the TIMSS instrument was qualitative.

The type of research methodology that was used, is survey research. Silverman (2000) classifies social surveys as one of the methods of quantitative research and deals mainly with fixed-choice questions to random samples. Since a suitable sample of learners' individual, responses over a vast area in the Western Cape was aimed at, survey research by using a questionnaire was regarded as the most appropriate method to gather data.

The survey using a questionnaire has its advantages and limitations. In general it is a quick and cheap process to obtain a lot of information covering a large area within a relatively short time. The supervision could be done with relative ease. The results can be analysed for quick action. In other words questionnaires in a relatively short space of time can be administered, analyzed and reported on. On the other hand, a large percentage of questionnaires are often never returned if the questionnaires are send to respondents to complete on their own. When respondents have difficulties with certain items on the questionnaire, it cannot be addressed due to the fact that there is a lack of face to face contact. In such case, the lack of response on several items reduces the reliability of responses.

3.2.2 Construction of the ROSME Instrument

One of the research instruments was the learners' questionnaire. With regards to the learners' questionnaire Julie and Mbekwa (2005, 33) stated the following about the development of the questionnaire:

> ... a survey instrument was developed around identified topics or clusters. The clusters were identified by mathematics educators from Zimbabwe, Uganda, Eritrea, Norway and a group of mathematics teachers from South Africa. Thirteen clusters including two intra-mathematical ones evolved through the identification process. The identification of the eleven extra-mathematical clusters was in a major way informed by modules and learning materials developed by the Consortium for Mathematics and its Applications (Garfunkel, 2004) to ensure compliance with the possible mathematical treatment of the cluster items which were developed as indicators of the identified clusters.

The instrument was developed from 2003 to 2005 by a number of roleplayers, namely mathematics educators from Zimbabwe, Uganda, Eritrea, Norway and a group of mathematics teachers from South Africa. Numerous gatherings were held in South Africa to adapt, change or add in order to have a quality instrument at hand. A pilot study was launched to assess the learners' questionnaire. The final one was compiled in January 2005 and contained 65 items.

The clusters, number of items in a cluster and an exemplar item are indicated in table 3.1:

Table 3.1 : Clusters : Intra-mathematical and Extra-mathematical

Cluster	Number of Items	Exemplar Indicator Item
Mathematics	6	Mathematics that will help me to do mathematics at universities and technikons
Mathematicians' Practices	5	How mathematicians make their discoveries
Health	5	Mathematics to prescribe the amount of medicine a sick person must take
Physical Science	2	Mathematics about renewable energy sources such as wind and solar power
Technology	4	Mathematics involved in making computer games such as play stations and TV games
General	9	Mathematics involved in military matters
Transport and delivery	4	Mathematics involved in designing delivery routes of goods such as delivering bread from a bakery to the shops
Life Science	5	How to predict the sex of a baby
Finance	5	Mathematics involved in working out financial plans for profit-making
Sport	3	Mathematics involved in my favourite sport
Youth Culture	5	Mathematics linked to South African pop music
Politics	4	Mathematics political parties use for election purposes
Agriculture	4	Mathematics needed to work out the amount of fertilizer needed to grow a certain crop

(See also appendix 2)

Learners had to respond to sixty one items. The response categories on the four-point Likert - type scale were "not at all interested", "a little bit interested", "interested" and "very interested" for the first sixty one items. The last four items required an open response. Qualitative data, the learners' reasons and drawings were also collected but this study does not deal with that data.

Another motivational factors for the use of this survey instrument was to include a relatively large number of items in order to cover as far as possible a vast range of items dealing with different contexts. The large number of items was to ensure that as many contexts as possible are covered to address the issue of validity.

3.2.3 TIMSS – Mathematics and Science Literacy items (Population 3)

The TIMSS Mathematical and Science Literacy achievement tests for Population 3 (students in their final year of secondary education) (1995; appendix 4) were also used as the other research instrument in this particular study. The determination of the contexts of the TIMSS test items fall in the paradigm of qualitative research.

Silverman (2000) stated the viewpoint of the qualitative critics that the issue of reliability is problematic citing Hammersley who refers to it as the degree of consistency with which instances are assigned to the same category by different observers or by the same observer on different occasions.

The TIMSS items were given without a cluster to 4 mathematics teachers and 2 subject advisors (see appendix 5). They were requested to provide a general category name for each item. From the provided category names I constructed a cluster classification of the items based on classifier-agreement and majority agreement. This was done to ensure reliability and validity of the classification of the TIMSS items (see appendix 6).

Although the TIMSS test includes science literacy items, only the mathematical literacy items were used. It was utilised to identify the contexts that the developers of the TIMSS instrument preferred to use as contexts. The frequency of items in a certain category were taken as a benchmark for designers' preference etc. if there were 5 items under sport against 2 for politics it is perceive that the test designers gave preference to sport as an extra-mathematical item. These data were used to compare with those of the ROSME instrument.

3.3 Sampling

The sample was a convenient and opportunistic one. Teachers attending courses at the University of the Western Cape (UWC) were requested to administer the instrument in their schools. Generally teachers attending courses at UWC, teach in areas characterized as those of low-socio-economic status. A whole class was selected in a grade. In other words in a particular school at least one grade 8, one grade 9 and one grade 10 class were targeted to complete the questionnaire. Where the opportunity exists to do more as the minimum target, teachers were free to do so. The grade 10 class was in this instance the learners that have mathematics as a subject, because mathematics was at that stage not compulsory. The learners involved ranged thus from Grade 8 to 10 and their ages from 13 – 22 years.

The sample of schools is also situated in urban and peri-urban regions of the Western Cape Province as indicated in table 3.2 below:

Table 3.2 : Regions of schools

Region Type	**Urban**	**Peri-urban**
District	Cape Peninsuala	West Coast, Boland, Southern Cape, Klein Karoo

Data of the grade 10 sample in terms of age (table 3.3), gender (table 3.4), language (table 3.5), and region (table 3.6) are displayed in the following tables:

Table 3.3: Age

Valid	**Age**	**Frequency**	**Percent**	**Valid Percent**	**Cumulative %**
	13	1	0.3	0.3	0.3
	14	35	9.0	9.0	9.2
	15	189	48.3	48.3	57.5
	16	110	28.1	28.1	85.7
	17	30	7.7	7.7	93.4
	18	14	3.6	3.6	96.9
	19	6	1.5	1.5	98.5
	20	5	1.3	1.3	99.7
	22	1	0.3	0.3	**100.0**
	Total	**391**	**100**	**100**	

Table 3.4: Gender

	Gender	**Frequency**	**Percent**	**Valid Percent**	**Cumulative %**
Valid	**Girl**	201	51.4	51.4	51.4
	Boy	190	48.6	48.6	**100.0**
	Total	**391**	**100.0**	**100.0**	

Table 3.5: Language

	Language	**Frequency**	**Percent**	**Valid Percent**	**Cumulative %**
Valid	**Afrikaans**	164	41.9	41.9	41.9
	English	227	58.1	58.1	**100.0**
	Total	**391**	**100.0**	**100.0**	

The questionnaires that were completed in English were mostly Xhosa-speaking learners whose language of instruction in schools is English.

Table 3.6: Region

	Region	**Frequency**	**Percent**	**Valid Percent**	**Cumulative %**
Valid	**Peri-Urban**	243	62.1	62.1	62.1
	Urban	148	37.9	37.9	**100.0**
		391	**100**	**100.0**	

3.4 Data Collection Processes

Data was collected in the different areas during March to June 2005. Student researchers went out to the different schools and in most cases physically steered this process in the class. Permission was obtained from the school managers or principals to collect data explaining to them what the purpose was and what would be done with the data. Learners were asked to participate voluntarily and could withdraw any time during the process. The student researcher went through each question with the participating learners in order to make sure that the learners understood the nature of each question or statement. This process was lengthy and due to logistics, the student researchers in some instances could not finish the collection process. It took more than a hour to complete the questionnaire whilst the length of a school period was on average fifty minutes. In such cases the particular mathematics teachers were asked to complete the process, thus the teachers only did the outstanding cases that the student researchers could not complete.

3.5 Data analysis procedure

Nonparametric procedures were used to analyse the ordinal data. Nonparametric procedures were developed to be used in cases when the researcher knows nothing about the parameters of the variable of interest in the population. It does not rely on the estimation of parameters describing the distribution of the variable of interest in the population.

A set of data is ordinal if the values/observations belonging to it can be ranked (put in order) or have a rating scale attached. The Kendall W-test was chosen to provide a mean ranking value of each item. The Kendall W (coefficient of concordance) test is used for expressing inter-rater agreement among independent judges who are rating (ranking) the same stimuli.

The Kendall W was used to rank the ROSME items (ordinal data) utilising the SPSS version 13.

3.6 Issues on reliability and validity

The research instrument, namely the learners' questionnaire was a product of regular changes and improvement by the ROSME group over a three year period. Instrument construction borders on judiciary inquiry and judgements and therefore the large number of mathematics educators and researchers from a number of countries made it possible for constructing a well thought-through learner's questionnaire and items dealing with a large variety of contextual situations and issues which could be dealt with in mathematical literacy and mathematics. The categorising of items went through a similar process.

Personal involvement of the student and principal researchers pertaining to data collection from the learners was the order of the day. The learner's questionnaire was not posted to schools. The researchers were on the site to give guidance and clarity on each item, making sure that uncertainty and the lack of understanding were to a large extent lessened.

As already explained learner's questionnaires on average took more than a hour to complete. Due to logistics in some instances student researchers had to rely on the mathematics teacher to run the process. Although the teachers were urged to do the data collection question by question, one could not guarantee that they had done it in the manner that was recommended.

3.7 Conclusion

The research instrument, the learners' questionnaire was used to personally collect data from schools in the Western Cape. Standardised data analysis procedures using SPSS version 13 were utilise. The data collected from the learners was to a large extent their individual response, which is an indication and confirmation of the reliability of the data since the expectation is to have such a response.

In the next chapter I will discuss the findings on the analysed data from the ROSME - and the TIMSS instrument.

Chapter 4

Findings

4.1 Introduction

In this chapter I will deal with the findings related to the ROSME instruments. The clusters as well as the analysis of the individual items will be focussed on. The findings from the analysis of the TIMSS instrument will be discussed according to clusters. A comparison will be drawn between the data of these two instruments, the ROSME and that of TIMSS.

4.2 Findings related to the ROSME Instrument

In general grade ten learners from low socio-economic environments prioritise the learning of mathematics as a discipline and interestingly enough, rate mathematician's practices next (figure 4.1). These two intra-mathematical clusters are rated the highest by this cohort of learners.

In table 4.1 the 6 individual items forms the mathematics cluster. (See also appendix 2 for the other clusters.) The cluster mean rankings were obtained by determining the average of the corresponding individual item mean rankings.

The two top preferred individual items in the mathematics clusters are "Mathematics that will help me to do mathematics at universities and technikons" and "Mathematics that is relevant to professionals such as engineers, lawyers and accountants." (table 4.1.)

Figure 4.1: ROSME Grade 10 Clusters

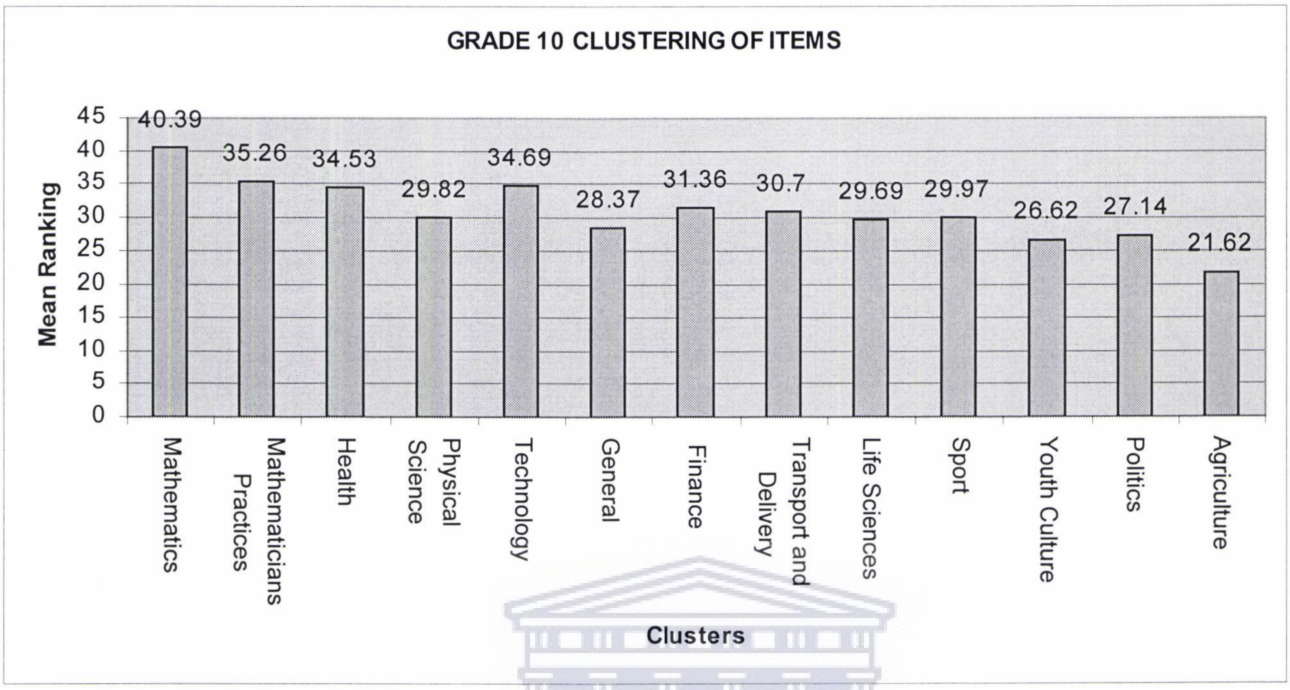


Table 4.1: Mathematics Cluster: Individual Ranked Items

Cluster	Mean Rank	Individual Items
Mathematics	49.57	Mathematics that will help me to do mathematics at universities and technikons
	45.57	Mathematics that is relevant to professionals such as engineers, lawyers and accountants
	42.68	Numbers
	39.83	Algebra
	37.15	Geometry
	27.29	Strange results and paradoxes in Mathematics

It shows that learners are quite aware that mathematics is a gateway subject that will give them access to higher education and the prospect of a meaningful career.

The extra-mathematical cluster that these grade 10 learners favoured is the technology cluster, closely followed by the health cluster (figure 4.1). Although these learners come from low socio-economic environments and schools, they are in connection with, exposed to and have access to these high technological devices. The individual item that is most highly preferred in this cluster is the mathematics involved in secret codes such as pin numbers used for withdrawing money from an ATM (table 4.2). ATM's are relatively accessible to the majority of South Africans and is the mechanism that is mostly used for the withdrawal of salaries. Interest in the mathematical inner workings of these modern "keys" (devices) is quite interesting given the fact that they are coming from low socio-economic environments.

Table 4.2: Technology Cluster: Individual Ranked Items

Cluster	Mean Rank	Individual Items
Technology	41.26	Mathematics involved in secret codes such as pin numbers used for withdrawing money from an ATM
	35.02	Mathematics involved in making computer games such as play stations and TV games
	31.80	Mathematics used in making aeroplanes and rockets
	30.78	Mathematics involved in dispatching a helicopter for rescuing people

The health of people is very high on the list of these grade 10 learners. One senses that learners value a person's health as a very important factor to pursue a quality life. Despite running numerous programmes educating people about HIV/AIDS and ways to try to prevent people to contract it, grade ten learners prefer to learn about mathematics to prescribe the amount of medicine a sick person must take (table 4.3). Do learners feel obliged to help the elderly who is dependent on the health services of hospitals and clinics where staff shortages hampered quality service delivery? Since this study did not track learners' reasons for choosing a particular item, I will not elaborate on this issue. Although the RNCS urge educators to use HIV/AIDS as a context through which mathematical literacy and mathematics could be studied, learners' choices show that they want to learn from health contexts that are not just limited to the HIV/AIDS context.

Table 4.3 : Health Cluster: Individual Ranked Items

Cluster	Mean Rank	Individual Items
Health	37.51	Mathematics to prescribe the amount of medicine a sick person must take
	36.41	How Mathematics is used to predict the spread of diseases caused by weapons of mass destruction such as chemical, biological and nuclear weapons
	35.82	Mathematics involved in determining the state of health of a person
	34.78	Mathematics used to predict the growth and decline of epidemics such as AIDS; tuberculosis
	27.93	Mathematics involved in determining levels of pollution

Analysing the ten highest-ranked individual extra-mathematical items that these grade 10's favour besides the technology and the health cluster items, "Mathematics involved in working out financial plans for profit-making" is the second most preferred extra-mathematical item (table 4.4). Living in a capitalist society it is not surprising that these learners from low socio-economic environments favour this item. It could be that they perceive profit-making as a means to escape their unfavourable economic circumstances.

Other items that feature in the top ten besides the technology and health (table 4.4), are

Fifth : Mathematics to assist in the determination of the level of development regarding employment, education and poverty of my community ;

Sixth : Mathematics used to calculate the taxes people and companies must pay to government and

Seventh : How mathematics is used to predict the spread of diseases caused by weapons of mass destruction such as chemical, biological and nuclear weapons.

One senses a trend of social consciousness amongst these grade ten learners. These items point to a large extent towards social welfare, care and social responsibility. It could be conjectured that learners are aware that if people pay taxes government has more capital to uplift communities and provide jobs for the unemployed. If the health items are also taken into account a element of caring not only for themselves, but also for the fellow community members is prominent. A comradely, a sharing and caring culture is prevalent in low socio-economic communities.

Table 4.4 :Highest Ranked Individual Items:Extra-Mathematical

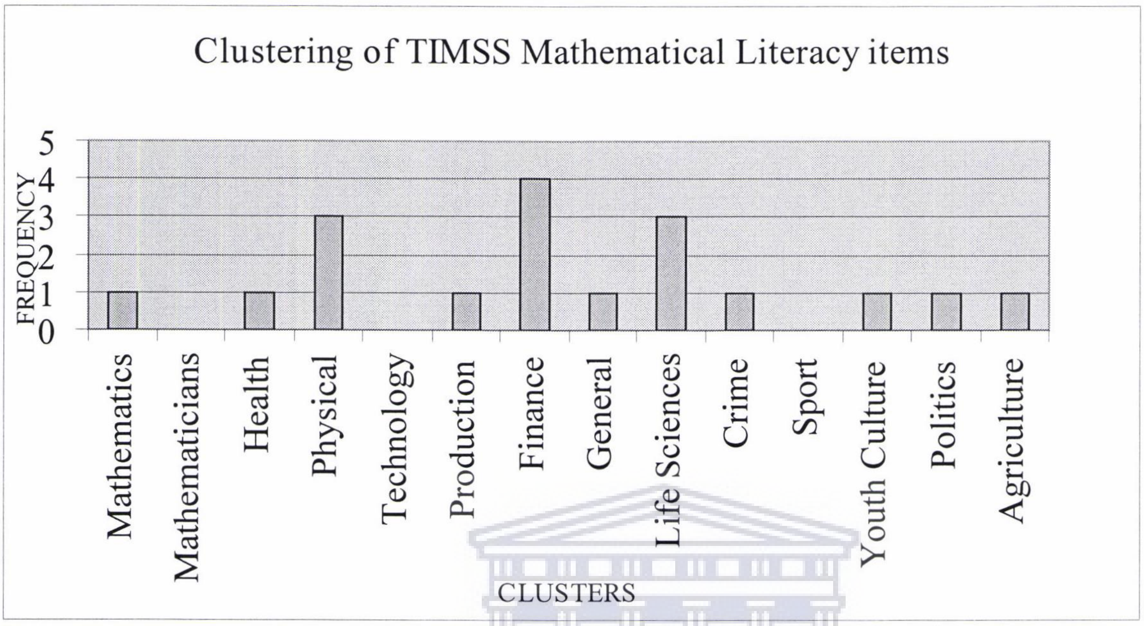
10 highest-ranked extra-mathematical items	Items	Mean Rank
	Mathematics that will help me to do mathematics at universities and technikons	49.60
	Mathematics that is relevant to professionals such as engineers, lawyers and accountants	45.58
	Numbers	42.78
	The kind of work mathematicians do	41.46
1	Mathematics involved in secret codes such as pin numbers used for withdrawing money from an ATM	41.32
2	Mathematics involved in working out financial plans for profit-making	41.02
	Algebra	39.93
	How mathematicians make their discoveries	38.21
3	Mathematics involved in sending of messages by SMS, cellphones and e-mails	37.74
4	Mathematics to prescribe the amount of medicine a sick person must take	37.60
5	Mathematics to assist in the determination of the level of development regarding employment, education and poverty of my community	37.48
6	Mathematics used to calculate the taxes people and companies must pay to the government	37.32
	Geometry	37.12
7	How mathematics is used to predict the spread of diseases caused by weapons of mass destruction such as chemical, biological and nuclear weapons	36.41
8	Mathematics involved in determining the state of health of a person	35.81
	Why mathematicians sometimes disagree	35.77
9	Mathematics that entertain and surprise us	35.56
	Mathematical ideas that have had a major influence in world affairs	35.10
10	Mathematics involved in making computer games such as playstations and TV games	35.04

(See also appendix 3)

4.3 Findings from the analysis of the TIMSS Instrument

The TIMSS instrument delivers the following results (figure 4.2):

Figure 4.2: Clustering of TIMSS Mathematical Literacy Items



Designers of the TIMSS mathematical literacy test items place a high premium on financial matters. Youth interest is built into these sales contexts, as well as technological devices. Youth culture is largely restricted to music and related objects and devices and is again indirectly implicated, if we also have to take into cognition the emphasis of the financial category**.** Although technology was not directly addressed, indirect references such as CD's , stereo systems, cars etc. implicates technological devices therefore sport as a category could be regarded as the item that has the lowest occurrence**.**

In contrast, no contexts of sport were covered by the TIMSS test.

The two clusters that were highly rated were life sciences and physical sciences. It is conjectured that designers were influenced by the fact that in the same test science literacy items were also covered. The designers of TIMSS probably concentrated on items related to other school subjects.

The other categories or clusters are treated evenly and no significant number of items in these categories is found to be highlighted or discussed.

4.4 Comparison of ROSME - and TIMSS findings

The two intra-mathematical clusters will not be taken into account in the comparison between the ROSME – and TIMSS findings. If one compares the extra-mathematical clusters there are differences and overlaps. I shall concentrate on the top and lowest favoured clusters of both instruments.

The two top clusters of favoured by designers of the TIMSS Mathematical Literacy items are the financial cluster with a strong youth culture element as well as technological gadgets that attracts the youths' attention. The other two clusters that they favoured were the life sciences and the physical science clusters. The interest of grade ten learners (ROSME) in life sciences and physical science as clusters can be regarded as standard.

The financial cluster of ROSME is quite high up learners' interest list. In fact an individual item of the financial cluster based on profit making is the second most favoured extra-mathematical item of learners. There is a natural historical trend to apply mathematics to financial issues and this emphasis on trade and financial matters steer the youth internationally to the importance of these matters.

The extra-mathematical cluster that most grade ten learners of ROSME favoured is the one on technology. As already mentioned although technology was not directly addressed by TIMSS designers, indirect references such as CD's, stereo systems, cars etc. implicate technological devices that were prominent at that particular time and age for the youth.

Another cluster that stands out in ROSME findings is the health cluster. Learners of grade ten are eager to learn mathematics and mathematical literacy through this cluster. TIMSS designers treated this cluster rather scantily.

The agriculture cluster was right at the bottom of the list of these grade ten learners of ROSME. Agriculture was also given low attention by the TIMSS designers.

The youth cluster was second-last according to the ROSME findings. To the contrary, TIMSS designers favoured several clusters (etc. financial and politics) with elements that are typical of the youth. One of the reasons that could be stated is that the designers are aware that they should colour these contexts with phenomena that will capture the interest of the youth. This outcome in ROSME is quite contradictory since one is under the impression that the youth will be eager to learn through situations and things that they can easily identify with.

Another unanticipated result is the absence of questions on sport in the TIMSS instrument, whilst the sport cluster was fifth on the list of favourites in the ROSME instrument. Grade ten learners coming from low socio-economic backgrounds are interested in learning mathematics through sport, whereas TIMSS designers do not see it as that important.

4.5 Conclusion

The ROSME instrument in figure 4.1 delivered the following findings with regards to the clusters: The intra-mathematical clusters, namely mathematics and mathematicians' practices are the most preferred clusters of the grade ten learners, whilst the extra-mathematical clusters, technology and health followed respectively the intra-mathematical clusters popularity of these grade tens. The lowest ranking clusters were agriculture and the youth culture.

The TIMSS instrument provided the following results: The financial cluster clouded by youth cultural elements and technological devices, life sciences and physical science were favoured by TIMSS designers. Sport as a cluster was not a favourite. In fact, no questions were set on this cluster.

The final chapter will deal with concluding remarks of this study.

Chapter 5

Conclusions and Recommendations

The outstanding result emerging from the analysis above is the high preference of grade ten learners to learn about Mathematics that will allow them to do tertiary studies and give them access to careers that were previously dominated by the privileged group in South Africa. Learners are aware that mathematics is a gateway subject. A concerted effort by the Department of Education (2004a) to emphasise the importance of mathematics could be regarded as successful in the sense that learners are well informed about the importance of mathematics. Learners coming from low socio-economic environments know that there is financial support available if results in mathematics are satisfactory and hence can pursue studies in careers where mathematics is a prerequisite. The emergence of special mathematics and science schools to serve learners coming from disadvantaged, low socio-economic environments are there to improve the quantity that take the subjects and the quality of mathematics and science results. This is indicative of the government's efforts to emphasise the importance of the subject.

The two top contextual clusters are technology and health. These grade 10 learners who are living under Third World conditions prefer to learn mathematics or mathematical literacy embedded in technological contexts that are typical of the First World. High technological devices such as cellphones, ATM's etc. which are reasonably accessible to this cohort of learners. These individual items regarding cellphones and pin-number for usage on ATM's are also amongst the ten most favoured extra-mathematical items. This illustrates also the complexity of the South African situation. Although these learners come from low socio-economic environments they know that the information explosion via technology is at the order of the day and they want to keep up with it.

As already mentioned health is one of the contextual domains that grade ten learners favour. Their interest is not confined just to HIV/AIDS as suggested and recommended by RNCS but they also want to express a need to address other aspects of health related issues. This is quite interesting given the fact that the HIV/AIDS is widely covered by the media and community awareness programmes.

Besides the mathematics, mathematicians practises cluster items grade tens favourite top ten extra-mathematical ROSME items points towards a trend of social consciousness amongst this cohort of learners.

The TIMSS instrument can be regarded as an adult designed instrument for learners. Designers regard financial issues as very important. The financial cluster was also high up the list of favourites of the grade ten learners. Elaboration on this issue will follow later.

Although this study focuses on the favourite items of grade ten learners it is also useful to look at the items or clusters that they did not rate as their favourites. The three lowest ranking clusters of the ROSME instrument are the agriculture, which is at the bottom of the list, the second lowest, youth culture, and the third from bottom cluster is, politics.

Most of these learners come from urban and peri-urban areas and therefore it could be one of the reasons that agriculture is at the bottom of their list. Agricultural items which involve environmental issues as well as sustainability are very low on the agenda of these grade ten learners. A lack of interest in agriculture through which mathematics or mathematical literacy could be learned is nevertheless evident from learners' choices.

A surprising result is the low interest to study mathematical literacy and mathematics through items that represent youth culture. It is perceived that learners like to wear these designer clothes and shoes and to listen to pop music, but they are not really interested in it as a context for mathematics and mathematical literacy. It is conjectured that the designing and making of clothes are confined to elderly people and associated with impoverished circumstances. My perception is that learners can't take hold of the idea that there are mathematics embedded in pop music, therefore the low interest in this item. This is in fact quite surprising. The general perception is that youth culture as a phenomenon would be a popular cluster because this is a thing that one normally associates with this cohort of learners.

Another rather interesting result is the low position of the political cluster. These learners are coming from communities that were previously excluded from the political democratic processes in South Africa. A long, proud history of fighting for political freedom is embedded in these communities who can tell their own stories about their efforts to reach this goal. The fact that learners show relatively very low interest in this cluster to study mathematical literacy or mathematics is quite contradictory. Although these grade ten learners have a strong sense for the social welfare of communities it seems as if they exclude the political democratic process from this conception. The motivation for such responses is lacking but it will be quite illuminating to follow up their reasons.

The item, gambling and lottery elicited the lowest interest of all the items. This response is also contradictory due to the fact that the lottery is the governments' initiative to generate funds for non-governmental organisations and participants could be instant millionaires. Government's involvement opened the gate for an immense amount of coverage by the media. Despite extensive coverage in terms of marketing and advertisement, live drawings on television etc. learners show very low interest in it. I can only speculate on the reasons why they do show not much interest in lottery and gambling. An age restriction prevents them to participate and therefore it could lead to lack of interest. Religious leaders are quite outspoken against gambling.

Hence, learners pay little interest in the lotto as well as playing it which could influence their perceptions on gambling. The moral and religious viewpoint on gambling and lottery seems to be influential in the decision of these grade tens in ranking it as the lowest preferred item.

On the other hand, TIMSS test designers place a high premium on financial issues, whereas technology and health related issues were high on the list of preferred items of the ROSME project. The notion of a global economy and the importance of financial matters are favoured and significantly promote the importance of these issues. Generally there is a notion that when a country or a region is economically vibrant and strong, it could lead to the alleviation of poverty. The stronger the economy, the more job opportunities will be available and in a sense provide the opportunity to increase the 'quality' of people's lives. Another factor that comes to the fore is the issue of globalisation which refers to the rapid spread of markets around the world and the expansion of economic linkages. To make it more youth friendly, TIMSS designers interweave these financial issues with youth cultural elements and youth related technological gadgets.

Surprisingly, TIMSS designers did not regard sport as that important and did not set one question related to sport. In other words sport was the lowest ranked item. Sport is relatively high on the agenda of the grade ten learners participated in the ROSME project. Sport is also a phenomenon that could be a community builder and more, a nation builder and as well a vehicle that can be used to counter the use of drugs and alcohol.

It is of utmost importance to be careful not to exclude contexts that could be of interest to the youth and beneficial in promoting it and exposing the youth to a healthy life style. These contextual preferences and those that lack interest can also be used to give more clarity to the notion of relevance. What learners find relevant or interesting may differ from what designers of tests may perceive to be relevant or vice versa.

The most important findings of this study are that grade ten learners from low socio-economic environments regard mathematics and mathematician's practices as the most favoured items. The extra-mathematical clusters that they prefer are the technology and health cluster. TIMSS designers favoured the financial cluster flavored with youth cultural elements and technological devices that the youth are associated with.

This study did not focus on the following, namely gender, age or regional preferences of contextual situations to study mathematical literacy or mathematics by grade 10 learners. Another approach towards these contexts is what contexts would the teachers favoured to use in mathematics or mathematical literacy. Generally teachers or adults use contexts which they perceived as useful and important or in most cases they perceive what contexts learners would favour.

Curriculum and test/examination designers, text book writers, mathematics and mathematical literacy teachers who seek to take into cognisance the interest of learners coming from low socio-economic environments could use this data and findings to influence their choices of contexts. This cohort of mathematics and mathematical literacy professionals do not have to guess what contexts interest grade ten learners, because this data could be used to capture their interest through which mathematics and mathematical literacy could be dealt with.

I would recommend them to use this study a powerful way to determine contexts for the learners. It is also open for further research in those areas that was not extensively covered by this study.

Finally, a constant review of learners' interest should take place, to be up to date with modern trends and devices that they favour to deal within mathematical literacy.

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APPENDIX 1

ROSME Questionnaire

CODE:…………………

RELEVANCE OF SCHOOL MATHEMATICS EDUCATION (ROSME)
January 2005

Things I'd like to learn about in Mathematics

I am: a female …… a male …..

I am ……. years old

I am in Grade …………….

What would you like to learn about in mathematics? Some possible things are in the list on the following pages. Beside each item in the list, circle only one of the numbers in the boxes to say how much you are interested. Please respond to all the items.

1 = Not at all interested
2 = A bit interested
3 = Quite interested
4 = Very interested

There are no correct answers: we want you to tell us what you like.
The items are not in any specific order of importance.

Thank you for your co-operation!

For office use	Things I'd like to learn about in Mathematics	Not at all interested	A bit interested	Quite interested	Very interested
C1	Mathematics linked to designer clothes and shoes	1	2	3	4
C2	Mathematics of a lottery and gambling	1	2	3	4
C3	Mathematics involved in making computer games such as play stations and TV games	1	2	3	4
C4	Why mathematicians sometimes disagree	1	2	3	4
C5	Mathematics used to predict the growth and decline of epidemics such as AIDS; tuberculosis and cholera	1	2	3	4
C6	The personal life stories of famous mathematicians	1	2	3	4
C7	Mathematics used in making aeroplanes and rockets.	1	2	3	4
C8	How to estimate and predict crop production	1	2	3	4
C9	Mathematics to predict whether certain species of animals are on the brink of extinction	1	2	3	4
C10	Mathematics political parties use for election purposes	1	2	3	4
C11	Mathematics that is relevant to professionals such as engineers, lawyers and accountants	1	2	3	4
C12	How mathematics is used to predict the spread of diseases caused by weapons of mass destruction such as chemical, biological and nuclear weapons	1	2	3	4
C13	Mathematics involved in designing delivery routes of goods such as delivering bread from a bakery to the shops.	1	2	3	4

For office use	Things I'd like to learn about in Mathematics	Not at all interested	A bit interested	Quite interested	Very interested
C14	Mathematics needed to work out the amount of fertilizer needed to grow a certain crop	1	2	3	4
C15	Mathematics involved in secret codes such as pin numbers used for withdrawing money from an ATM	1	2	3	4
C16	Mathematics used to calculate the taxes people and companies must pay to the government	1	2	3	4
C17	Mathematics involved for deciding the number of cattle, sheep or reindeer to graze in a field of a certain size	1	2	3	4
C18	Mathematics of inflation	1	2	3	4
C19	Mathematics about renewable energy sources such as wind and solar power	1	2	3	4
C20	Mathematics involved in determining the state of health of a person	1	2	3	4
C21	Mathematics to assist in the determination of the level of development regarding employment, education and poverty of my community	1	2	3	4
C22	Mathematics to prescribe the amount of medicine a sick person must take	1	2	3	4
C23	Mathematics that will help me to do mathematics at universities and technikons	1	2	3	4
C24	Mathematics involved in the placement of emergency services such as police stations, fire brigades and ambulance stations so that they can reach emergency spots in the shortest possible time	1	2	3	4
C25	Mathematics involved in making complex structures such as bridges	1	2	3	4
C26	The kind of work mathematicians do	1	2	3	4

For office use	Things I'd like to learn about in Mathematics	Not at all interested	A bit interested	Quite interested	Very interested
C27	Geometry	1	2	3	4
C28	Mathematics involved in packing goods to use space efficiently	1	2	3	4
C29	How mathematicians make their discoveries	1	2	3	4
C30	Mathematics linked to South African pop music	1	2	3	4
C31	Mathematics used to calculate the number of seats for parliament given to political parties after elections	1	2	3	4
C32	Mathematics involved in assigning people to tasks when a set of different tasks must be completed	1	2	3	4
C33	Blunders and mistakes some mathematicians have made	1	2	3	4
C34	Algebra	1	2	3	4
C35	Mathematics about the age of the universe	1	2	3	4
C36	Mathematics involved in working out the best arrangement for planting seeds	1	2	3	4
C37	Mathematics to determine the number of fish in a lake, river or a certain section of the sea	1	2	3	4
C38	Mathematics linked to music from the United States, Britain and other such countries	1	2	3	4
C39	Mathematics that air traffic controllers use for sending off and landing planes	1	2	3	4
C40	Mathematics linked to rave and disco dance patterns	1	2	3	4
C41	Mathematics involved in making pension and retirement schemes	1	2	3	4
C42	Mathematics of the storage of music on CD's	1	2	3	4

For office use	Things I'd like to learn about in Mathematics	Not at all interested	A bit interested	Quite interested	Very interested
C43	Mathematics linked to decorations such as the house decorations made by Ndebele women	1	2	3	4
C44	Mathematical ideas that have had a major influence in world affairs	1	2	3	4
C45	Numbers	1	2	3	4
C46	Mathematics involved in sending of messages by SMS, cellphones and e-mails	1	2	3	4
C47	Mathematics involved in working out financial plans for profit-making	1	2	3	4
C48	Mathematics involved in my favourite sport	1	2	3	4
C49	Mathematics involved in dispatching a helicopter for rescuing people	1	2	3	4
C50	Mathematics used to work out the repayments (instalment) for things bought on credit are worked out	1	2	3	4
C51	How to predict the sex of a baby	1	2	3	4
C52	How mathematics can be used for setting up a physical training program, and measure fitness.				
C53	Strange results and paradoxes in Mathematics				
C54	Mathematics to monitor the growth of a baby for the first period of life	1	2	3	4
C55	Mathematics that entertain and surprise us.	1	2	3	4
C56	Mathematics to describe facts about diminishing rain forest and growing deserts.	1	2	3	4

For office use	Things I'd like to learn about in Mathematics	Not at all interested	A bit interested	Quite interested	Very interested
C57	How mathematics can be used in planning a journey	1	2	3	4
C58	How mathematics can be used in sport competitions like ski jumping, athletics, aerobics, swimming, gymnastics and soccer.	1	2	3	4
C59	Mathematics to describe movement of big groups of people in situations such as emigration and refugees fleeing from their countries.	1	2	3	4
C60	Mathematics involved in determining levels of pollution.	1	2	3	4
C61	Mathematics involved in military matters.	1	2	3	4

C62 Please write down 3 issues that you are very interested in learning about the use of mathematics in these issues.

(a) ....

(b) ....

(c) ....

Why are you interested in these issues?

....

....

....

....

C63 Are you interested in learning something in mathematics that arises while you are learning other school subjects?

YES NO

Why? .... Why not? ....

....

....

....

C64 Are you interested in learning something on mathematics related to issues that have been in the newspapers or radio or TV recently?

YES NO

Why? .... Why not? ....

....

....

C65 Make a sketch or drawing of a mathematician working.

Appendix 2 : Clustering of ROSME instrument

Cluster Number of Items	Mean Ranking	Exemplar Indicator Item
Mathematics	49.60	Mathematics that will help me to do mathematics at universities and technikons
(6)	37.12	Geometry
	42.78	Numbers
	45.58	Mathematics that is relevant to professionals such as engineers, lawyers and accountants
	39.93	Algebra
	27.31	Strange results and paradoxes in Mathematics
	40.39	
Mathematicians' Practices	38.21	How mathematicians make their discoveries
	41.46	The kind of work mathematicians do
	35.77	Why mathematicians sometimes disagree
	28.08	Personal life stories of famous mathematicians
(5)	32.79	Blunders and mistakes some mathematicians have made
	35.26	
Health	37.60	Mathematics to prescribe the amount of medicine a sick person must take
(5)	35.81	Mathematics involved in determining the state of health of a person
	36.41	How Mathematics is used to predict the spread of diseases caused by weapons of mass destruction such as chemical, biological and nuclear weapons
	34.91	Mathematics used to predict the growth and decline of epidemics such as AIDS; tuberculosis
	27.94	Mathematics involved in determining levels of pollution
	34.53	
Physical Science	31.30	Mathematics about renewable energy sources such as wind and solar power
(2)	28.34	Mathematics involved in making complex structures such as bridges
	29.82	
Technology	35.04	Mathematics involved in making computer games such as play stations and TV games
(4)	41.32	Mathematics involved in secret codes such as pin numbers used for withdrawing money from an ATM
	30.75	Mathematics involved in dispatching a helicopter for rescuing people
	31.68	Mathematics used in making aeroplanes and rockets
	34.69	

General (9)	30.36	Mathematics involved in military matters
	17.60	Mathematics of a lottery and gambling
	37.48	Mathematics to assist in the determination of the level of development regarding employment, education and poverty of my community
	32.99	Mathematics about the age of the universe
	35.56	Mathematics that entertain and surprise us
	35.10	Mathematics that have a major influence in world affairs
	21.56	Mathematics involved in packing goods to use space efficiently
	18.56	Mathematics linked to decorations such as the house decorations made by Ndebele women
	26.12	Mathematics involved in assigning people to tasks when a set of different tasks must be completed
	28.37	
		Finance
Finance (5)	41.02	Mathematics involved in working out financial plans for profit-making
	25.62	How mathematics can be used in planning a journey
	27.25	Mathematics involved in making pension and retirement schemes
	28.96	Mathematics of inflation
	33.95	Mathematics used to work out the repayments (instalment) for things bought on credit are worked out
	31.36	
Transport and delivery (4)	18.70	Mathematics involved in designing delivery routes of goods such as delivering bread from a bakery to the shops
	37.74	Mathematics involved the sending of messages by SMS, cellphones and e-mails
	34.75	Mathematics involved in the placement of emergency services such as police stations, fire brigades and ambulance stations so that they can reach emergency spots in the shortest possible time
	31.61	Mathematics that air traffic controllers use for sending off and landing planes
	30.70	

Life Science **(5)**	34.75 25.16 31.19 24.26 33.07 **29.69**	How to predict the sex of a baby Mathematics to determine the number of fish in a lake, river or a certain section of the sea Mathematics to predict whether certain species of animals are on the brink of extinction Mathematics to describe facts about diminishing rain forest and growing deserts Mathematics to monitor the growth of a baby the first period of life
Sport **(3)**	29.19 29.13 31.59 **29.97**	Mathematics involved in my favourite sport How mathematics can be used in sport competitions like ski jumping, athletics, aerobic, swimming, gymnastics and soccer How mathematics can be used by setting up a physical training program and measure fitness
Youth Culture **(5)**	26.01 27.34 25.62 21.39 32.74 **26.62**	Mathematics linked to South African pop music Mathematics linked to music from the United States, Britain and other countries Mathematics linked to rave and disco dance patterns Mathematics linked to designer clothes and shoes Mathematics of the storage of music on CD's
Politics **(4)**	22.98 22.73 37.32 25.51 **27.14**	Mathematics political parties use for election purposes Mathematics used to calculate the number of seats for parliament given to political parties after elections Mathematics used to calculate the taxes people and companies must pay to the governments Mathematics to describe movement of big groups of people in situations such as emigration and refugees fleeing from their countries
Agriculture **(4)**	19.84 21.61 25.16 19.88 **21.62**	Mathematics needed to work out the amount of fertilizer needed to grow a certain crop Mathematics involved in working out the best arrangement for planting seeds. How to estimate and project crop production Mathematics involved for deciding the number of cattle to graze in a field of a certain size

Appendix 3

Grade 10 data:

Ranks

	Mean Rank
Mathematics that will help me to do mathematics at universities and technikons	49.60
Mathematics that is relevant to professionals such as engineers, lawyers and accountants	45.58
Numbers	42.78
The kind of work mathematicians do	41.46
Mathematics involved in secret codes such as pin numbers used for withdrawing money from an ATM	41.32
Mathematics involved in working out financial plans for profit-making	41.02
Algebra	39.93
How mathematicians make their discoveries	38.21
Mathematics involved in sending of messages by SMS, cellphones and e-mails	37.74
Mathematics to prescribe the amount of medicine a sick person must take	37.60
Mathematics to assist in the determination of the level of development regarding employment, education and poverty of my community.	37.48
Mathematics used to calculate the taxes people and companies must pay to the government	37.32
Geometry	37.12
How mathematics is used to predict the spread of diseases caused by weapons of mass destruction such as chemical, biological and nuclear weapons	36.41
Mathematics involved in determining the state of health of a person	35.81
Why mathematicians sometimes disagree	35.77
Mathematics that entertain and surprise us	35.56
Mathematical ideas that have had a major influence in world affairs	35.10
Mathematics involved in making computer games such as play stations and TV games	35.04
Mathematics used to predict the growth and decline of epidemics such as AIDS; tuberculosis and cholera	34.91

How to predict the sex of a baby	34.75
Mathematics involved in the placement of emergency services such as police stations, fire brigades and ambulance stations so that they can reach emergency spots in the shortest possible time	34.62
Mathematics used to work out the repayments (instalment) for things bought on credit are worked out	33.95
Mathematics to monitor the growth of a baby the first period of life	33.07
Mathematics about the age of the universe	32.99
Blunders and mistakes some mathematicians have made	32.79
Mathematics of the storage of music on CD's	32.74
Mathematics used in making aeroplanes and rockets.	31.68
Mathematics that air traffic controllers use for sending off and landing planes	31.61
How mathematics can be used by setting up a physical training program, and measure fitness	31.59
Mathematics about renewable energy sources such as wind and solar power	31.30
Mathematics to predict whether certain species of animals are on the brink of extinction	31.19
Mathematics involved in dispatching a helicopter for rescuing people	30.75
Mathematics involved in military matters	30.36
Mathematics involved in my favourite sport	29.19
How mathematics can be used in sport competitions like ski jumping, athletics, aerobic, swimming, gymnastics and soccer	29.13
Mathematics of inflation	28.96
Mathematics involved in making complex structures such as bridges	28.34
The personal life stories of famous mathematicians	28.08
Mathematics involved in determining levels of pollution	27.94
Mathematics linked to music from the United States, Britain and other such countries	27.34
Strange results and paradoxes in Mathematics	27.31
Mathematics involved in making pension and retirement schemes	27.25

Mathematics involved in assigning people to tasks when a set of different tasks must be completed	26.12
Mathematics linked to South African pop music	26.01
How mathematics can be used in planning a journey	25.64
Mathematics linked to rave and disco dance patterns	25.62
Mathematics to describe movement of big groups of people in situations such as emigration and refugees fleeing from their countries	25.51
How to estimate and project crop production	25.16
Mathematics to determine the number of fish in a lake, river or a certain section of the sea	25.16
Mathematics to describe facts about diminishing rain forest and growing deserts	24.26
Mathematics political parties use for election purposes	22.98
Mathematics used to calculate the number of seats for parliament given to political parties after elections	22.73
Mathematics involved in working out the best arrangement for planting seeds	21.61
Mathematics involved in packing goods to use space efficiently	21.56
Mathematics linked to designer clothes and shoes	21.39
Mathematics involved for deciding the number of cattle, sheep or reindeer to graze in a field of a certain size	19.88
Mathematics needed to work out the amount of fertilizer needed to grow a certain crop	19.84
Mathematics involved in designing delivery routes of goods such as delivering bread from a bakery to the shops	18.70
Mathematics linked to decorations such as the house decorations made by Ndebele women	18.56
Mathematics of a lottery and gambling	17.60

APPENDIX 4

TIMSS Mathematical and Science Literacy Items

Released Mathematics and Science Literacy Items Population 3

IEA TIMSS

A3. Experts say that 25% of all serious bicycle accidents involve head injuries and that, of all head injuries, 80% are fatal.

What percentage of all serious bicycle accidents involve fatal head injuries?

A. 16%

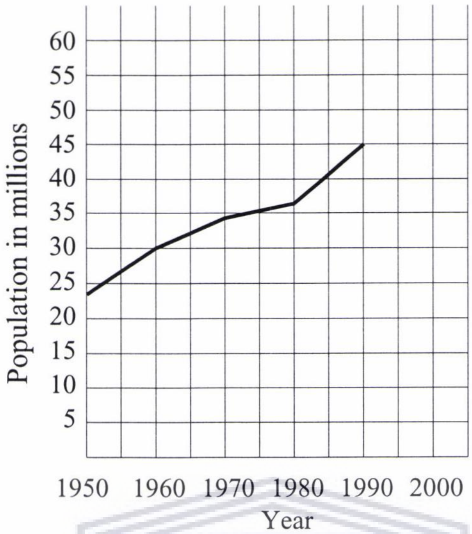
B. 20%

C. 55%

D. 105%

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	B	Mathematics Literacy	Complex Procedures	64%	488

A4. If the population increases by the same rate from the year 1990 to the year 2000 as in the years from 1980 to 1990, approximately what is the expected population by the year 2000?



A. 47 million

B. 50 million

C. 53 million

D. 58 million

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	C	Mathematics Literacy	Complex Procedures	72%	452

A5. A school club is planning a bus trip to the wildlife park. A bus which will hold up to 45 people will cost 600 centros (units of money) and admission tickets cost 30 centros each.

If the cost of the trip, including bus and admission ticket, is set at 50 centros per person, what is the minimum number of people who must participate to ensure that these costs are covered?

A. 12

B. 20

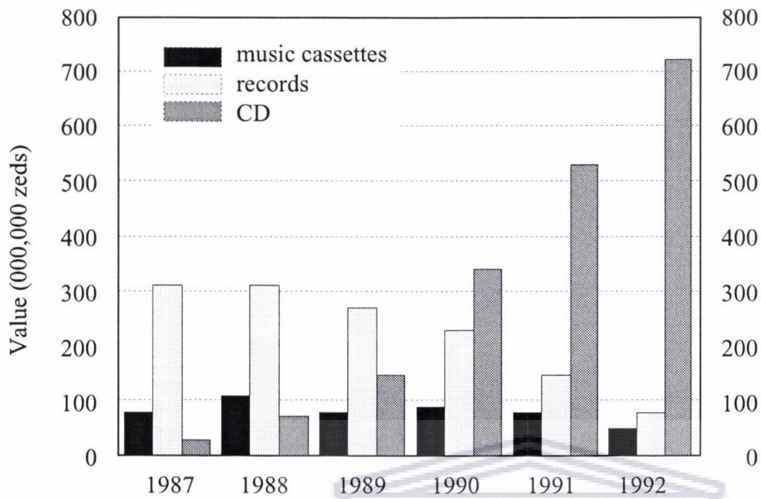
C. 30

D. 45

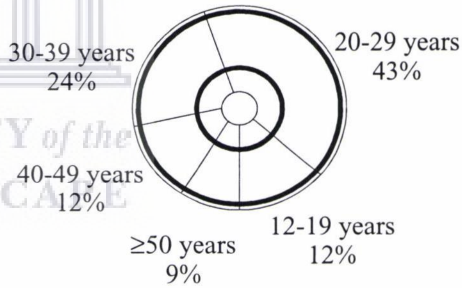
Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	C	Mathematics Literacy	Solving Problems	50%	555

A8. The graphs give information about sales of CDs and other sound recording media in Zedland. Zeds are the monetary units used in Zedland.

Value of various sound recording media sold in Zedland (millions of zeds)



CD sales according to age in 1992



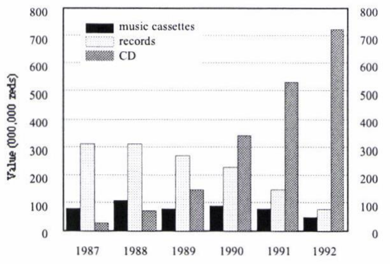
With the aid of both graphs calculate how much money was spent by 12-19 year olds on CDs in 1992. Show your work.

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Solving Problems	44%	573

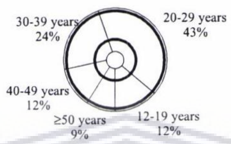
A-8 Coding Guide

A8. The graphs give information about sales of CDs and other sound recording media in Zedland. Zeds are the monetary units used in Zedland.

Value of various sound recording media sold in Zedland (millions of zeds)



CD sales according to age in 1992



With the aid of both graphs calculate how much money was spent by 12-19 year olds on CDs in 1992. Show your work.

Note: Do not deduct for not including units of zeds in response.

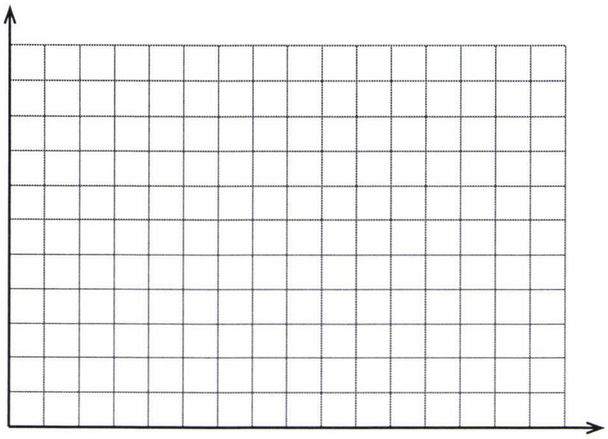
Code	Response
	Correct Response
20	Answer: 86.4 million zeds (or equivalent). Explanation or method shown. *Example:* $(720 \times 1{,}000{,}000) \times (12 \div 100) = 86{,}400{,}000$
21	Answer in the range of 84 to 87.6 million zeds (or equivalent). Explanation or method shown.
	Partial Response
10	Answer in the range of 84 to 87.6 million zeds (or equivalent). No explanation or method shown.
11	Answer in the range of 84 to 87.6 zeds (or equivalent). Factor of 1 million is omitted. Explanation or method shown.
12	Answer outside range due to place value (decimal) error. Explanation or method shown. *Example:* $(710{,}000 \div 100) \times 12 = 85{,}200$
13	Includes some correct calculations, but final answer is missing or incorrect: *Examples: Calculation correct:* $((700 \text{ to } 730) \div 100) \times 12))$; *no final answer.* *Calculation includes a computational error (other than Code 12)*
19	Other partial.

Continued Next Page

A-8 Coding Guide (Continued)

Incorrect Response		
70	Applies incorrect value of CDs. Calculates or attempts to calculate 12% of this value.
71	Applies correct value of CDs. Indicates incorrect calculation of 12%; eg. subtraction or division by 12.
79	Other incorrect.
Nonresponse		
90	Crossed-out/erased, illegible, or impossible to interpret.
99	BLANK

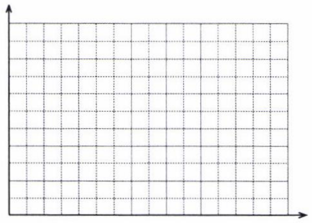
A10. Using the set of axes below, sketch a graph which shows the relationship between the height of a person and his/her age from birth to 30 years. Be sure to label your graph, and include a realistic scale on each axis.



Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Justifying and Proving	19%	685

A-10 Coding Guide

A10. Using the set of axes below, sketch a graph which shows the relationship between the height of a person and his/her age from birth to 30 years. Be sure to label your graph, and include a realistic scale on each axis.



Code	Response
	Correct Response
20	All the following features correct: 1. Correct scales and labels on both axes: Age: 0 - 30 years Height: 0 - 200 cm OR 0 - 80 inches (0 - 7 ft) 2. The graph starts at approximately 50 cm (20 inches). 3. Maximum height is reached at a realistic age (14 to 20 years). 4. The graph is horizontal after age of maximum height. 5. Maximum height is reasonable.
	Partial Response
10	Incorrect start of graph. Other features correct. *Examples: Graph starts at height of zero.* *Graph does not start at year zero.*
11	Unrealistic age for maximum height. Other features correct.
12	Incorrect graph after age of maximum height. Other features correct. *Examples: Graph continuously increases in the range of 20 - 30 years.* *Graph decreases after age of maximum height.*
13	Includes incorrect scales or labels. Other features correct.
19	Other partial.
	Incorrect Response
70	Includes incorrect start of graph AND incorrect scales. Other features correct.
71	Includes incorrect start of graph AND incorrect graph after age of maximum height. Other features correct.
79	Other incorrect.
	Nonresponse
90	Crossed-out/erased, illegible, or impossible to interpret.
99	BLANK

A12. The following two advertisements appeared in a newspaper in a country where the units of currency are *zeds*.

BUILDING A	BUILDING B
Office space available	Office space available
85 - 95 square meters 475 *zeds* per month	35 - 260 square meters 90 *zeds* per square meter per year
100 - 120 square meters 800 *zeds* per month	

If a company is interested in renting an office of 110 square meters in that country for a year, at which office building, A or B, should they rent the office in order to get the lower price? Show your work.

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Communicating	50%	554

A-12 Coding Guide

A12. The following two advertisements appeared in a newspaper in a country where the units of currency are *zeds*.

BUILDING A	BUILDING B
Office space available	Office space available
85 - 95 square meters	35 - 260 square meters
475 *zeds* per month	90 *zeds* per square meter per year
100 - 120 square meters 800 *zeds* per month	

If a company is interested in renting an office of 110 square meters in that country for a year, at which office building, A or B, should they rent the office in order to get the lower price? Show your work.

Note: There is no distinction made between responses with and without units

Code	Response
	Correct Response
30	Building A. Correct calculation of rents for both buildings. 9600/800 AND 9900/825, or 825 to compare with the 800 given.
39	Other correct
	Partial Response
20	Building A. Correct calculation of rent for Building A OR B but not both.
21	Building B OR building is not named. Correct calculation of rents for both buildings.
	Minimal Response
10	Building A. Calculations or explanation are incorrect or inadequate.
11	Building A. No work shown.
12	Building B, OR building is not named. Correct calculation of rent for Building A OR B but not both.
16	Building A. Explanation is given only in the form of extracts from the advertisements.
19	Other partial.
	Incorrect Response
70	Building B. Incorrect or inadequate calculations.
71	Building B. No work shown.
79	Other incorrect.
	Nonresponse
90	Crossed out/erased, illegible, or impossible to interpret.
99	BLANK

D6. A 45 000-litre water tank is to be filled at the rate of 220 liters per minute.

Estimate, to the nearest half an hour, how long it will take to fill the tank.

A. 4 hours

B. $3\frac{1}{2}$ hours

C. 3 hours

D. $2\frac{1}{2}$ hours

D-6

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	B	Mathematics Literacy	Complex Procedures	65%	487

D7. If there are 300 calories in 100 grams of a certain food, how many calories are there in a 30 gram portion of that food?

A. 90

B. 100

C. 900

D. 1000

E. 9000

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	A	Mathematics Literacy	Knowing	71%	451

D8. In a vineyard there are 210 rows of vines. Each row is 192 m long and plants are planted 4 m apart. On average, each plant produces 9 kg of grapes each season.

The total amount of grapes produced by the vineyard each season is closest to

A. 10 000 kg

B. 100 000 kg

C. 400 000 kg

D. 1 600 000 kg

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	B	Mathematics Literacy	Complex Procedures	55%	531

D9. A store is having a '20% off' sale. The normal price of a <stereo system> is $1250.

What is the price of the <stereo system> after the 20% discount is applied?

A. $1000

B. $1050

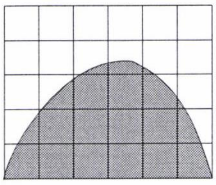
C. $1230

D. $1500

D-9

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	A	Mathematics Literacy	Routine Procedures	72%	450

D10.



Each of the small squares in the figure is 1 square unit. Which is the best estimate of the area of the shaded region?

A. 10 square units

B. 12 square units

C. 14 square units

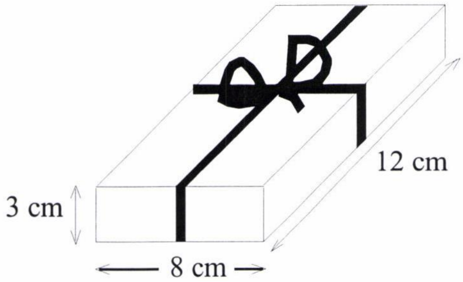
D. 16 square units

E. 18 square units

D-10

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	C	Mathematics Literacy	Knowing	61%	507

D11. Stu wants to wrap some ribbon around a box as shown and have 25 cm left to tie a bow.



How long a piece of ribbon does he need?

A. 46 cm

B. 52 cm

C. 65 cm

D. 71 cm

E. 77 cm

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	E	Mathematics Literacy	Complex Procedures	45%	575

D12. Brighto soap powder is packed in cube-shaped cartons. A carton measures 10 cm on each side.

The company decides to increase the length of each edge of the carton by 10 per cent.

How much does the volume increase?

A. 10 cm^3

B. 21 cm^3

C. 100 cm^3

D. 331 cm^3

D-12

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	D	Mathematics Literacy	Solving Problems	31%	646

D13. In a school election with three candidates, Joe received 120 votes, Mary received 50 votes, and George received 30 votes.

What percentage of the total number of votes did Joe receive?

A. 60%

B. $66\frac{2}{3}\%$

C. 80%

D. 120%

D-13

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	A	Mathematics Literacy	Routine Procedures	64%	488

D14. From a batch of 3000 light bulbs, 100 were selected at random and tested. If 5 of the light bulbs in the sample were found to be defective, how many defective light bulbs would be expected in the entire batch?

A. 15

B. 60

C. 150

D. 300

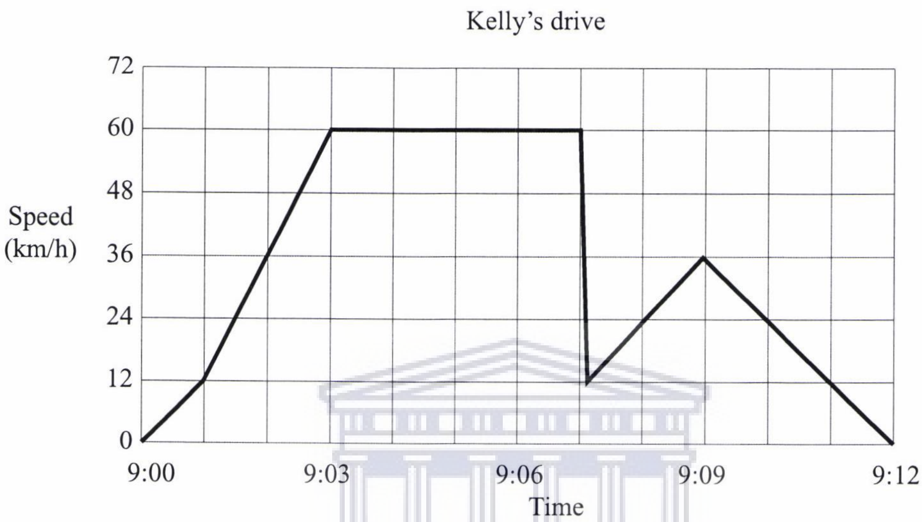
E. 600

D-14

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	C	Mathematics Literacy	Solving Problems	66%	478

D15. Kelly went for a drive in her car. During the drive, a cat ran in front of the car. Kelly slammed on the brakes and missed the cat.

Slightly shaken, Kelly decided to return home by a shorter route. The graph below is a record of the car's speed during the drive.



D-15a

a) What was the maximum speed of the car during the drive?

____

b) What time was it when Kelly slammed on the brakes to avoid the cat?

____

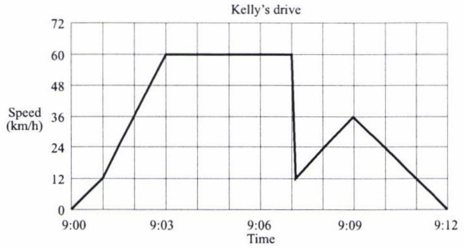
Part a

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Solving Problems	74%	435

D-15a Coding Guide

D15. Kelly went for a drive in her car. During the drive, a cat ran in front of the car. Kelly slammed on the brakes and missed the cat.

Slightly shaken, Kelly decided to return home by a shorter route. The graph below is a record of the car's speed during the drive.



a) What was the maximum speed of the car during the drive?

____

b) What time was it when Kelly slammed on the brakes to avoid the cat?

____

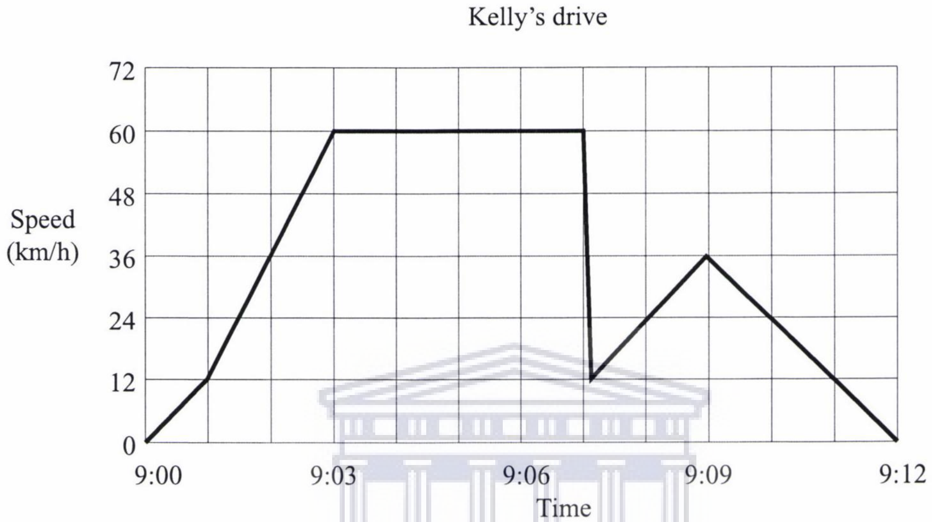
A: Codes Maximum Speed of Car

Note: Do not deduct for not including units.

Code	Response
	Correct Response
10	60 km/h.
	Incorrect Response
79	Any incorrect response.
	Nonresponse
90	Crossed-out/erased, illegible or impossible to interpret.
99	BLANK

D15. Kelly went for a drive in her car. During the drive, a cat ran in front of the car. Kelly slammed on the brakes and missed the cat.

Slightly shaken, Kelly decided to return home by a shorter route. The graph below is a record of the car's speed during the drive.



a) What was the maximum speed of the car during the drive?

____

b) What time was it when Kelly slammed on the brakes to avoid the cat?

____

Part b

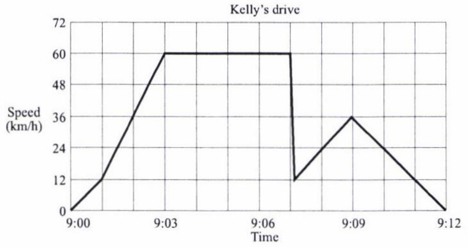
Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Solving Problems	59%	512

D-15b

D-15b Coding Guide

D15. Kelly went for a drive in her car. During the drive, a cat ran in front of the car. Kelly slammed on the brakes and missed the cat.

Slightly shaken, Kelly decided to return home by a shorter route. The graph below is a record of the car's speed during the drive.



a) What was the maximum speed of the car during the drive?

____

b) What time was it when Kelly slammed on the brakes to avoid the cat?

____

B: Codes Times Slammed on Brakes

Code	Response
	Correct Response
10	9:07.
	Incorrect Response
70	9:06.
71	Answers between 9:06 and 9:07, exclusive.
72	Answers shortly after 9:07. *Examples: It was approximately 9:07 and 10 seconds, when Kelly slammed on the brakes to avoid the cat.* *Approximately 9:07 and 2 seconds.*
79	Other incorrect.
	Nonresponse
90	Crossed-out/erased, illegible or impossible to interpret.
99	BLANK

D16. Teresa wants to record 5 songs on tape. The length of time each song plays for is shown in the table.

Song	Length of Time
1	2 minutes 41 seconds
2	3 minutes 10 seconds
3	2 minutes 51 seconds
4	3 minutes
5	3 minutes 32 seconds

Estimate to the nearest minute the total time taken for all five songs to play and explain how this estimate was made.

Estimate: ______________

Explain:

D-16a

Estimate

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Solving Problems	39%	600

D-16a Coding Guide

D16. Teresa wants to record 5 songs on tape. The length of time each song plays for is shown in the table.

Song	Length of Time
1	2 minutes 41 seconds
2	3 minutes 10 seconds
3	2 minutes 51 seconds
4	3 minutes
5	3 minutes 32 seconds

Estimate to the nearest minute the total time taken for all five songs to play and explain how this estimate was made.

Estimate ____________

Explain:

A: Codes for Total Estimate

Code	Response
	Correct Response
10	15 minutes
11	16 minutes
	Incorrect Response
70	13 minutes
71	14 minutes
72	15 min. 14 sec
73	17 minutes
79	Other incorrect
	Nonresponse
90	Crossed out/erased, illegible, or impossible to interpret.
99	BLANK

D16. Teresa wants to record 5 songs on tape. The length of time each song plays for is shown in the table.

Song	Length of Time
1	2 minutes 41 seconds
2	3 minutes 10 seconds
3	2 minutes 51 seconds
4	3 minutes
5	3 minutes 32 seconds

Estimate to the nearest minute the total time taken for all five songs to play and explain how this estimate was made.

Estimate: ______________

Explain:

D-16b

Explain

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Solving Problems	32%	635

D-16b Coding Guide

D16. Teresa wants to record 5 songs on tape. The length of time each song plays for is shown in the table.

Song	Length of Time
1	2 minutes 41 seconds
2	3 minutes 10 seconds
3	2 minutes 51 seconds
4	3 minutes
5	3 minutes 32 seconds

Estimate to the nearest minute the total time taken for all five songs to play and explain how this estimate was made.

Estimate ____________

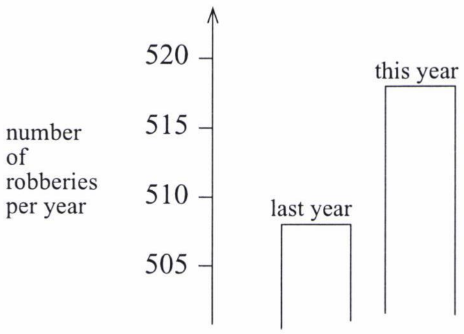
Explain:

B: Codes for Explanation

Code	Response
	Correct Response
10	Each amount of time is correctly rounded to whole minutes before adding. *Example:* $3 + 3 + 3 + 3 + 4$ *OR* $3 + 3 + 3 + 3 + 3$
11	Each amount of time is correctly rounded to nearest 5,10,15 or 30 seconds.
12	No calculation shown. Statements may include “rounded off to nearest minute”, “rounded the numbers up and down” or similar expressions.
13	Adds correctly and then rounds off from 15 min. 14 sec.
19	Other correct.
	Incorrect Response
70	Each amount of time is rounded off, but one or more rounding is incorrect.
71	Rounds off from 14 min. 34 sec.
79	Other incorrect
	Nonresponse
90	Crossed out/erased, illegible, or impossible to interpret.
99	BLANK

D17. A TV reporter showed this graph and said:

"There's been a huge increase in the number of robberies this year."



Do you consider the reporter's statement to be a reasonable interpretation of the graph? Briefly explain.

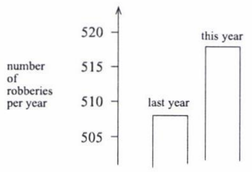
D-17

Subject	Item Key	Content Category	Performance Expectation	International Average Percent of Students Responding Correctly	International Difficulty Index
Mathematics Literacy	next page	Mathematics Literacy	Knowing	19%	681

D-17 Coding Guide

D17. A TV reporter showed this graph and said:

"There's been a huge increase in the number of robberies this year."



Do you consider the reporter's statement to be a reasonable interpretation of the graph? Briefly explain.

Note: The use of NO in these codes includes all statements indicating that the interpretation of the graph is NOT reasonable. YES includes all statements indicating that the interpretation is reasonable.

Code	Response
	Correct Response
20	NO. Focuses on the fact that only a small part of the graph is shown. *Examples: Not reasonable. The entire graph should be displayed.* *I don't think it is a reasonable interpretation of the graph because if they were to show the whole graph you would see that there is only a slight increase in robberies.*
21	NO. Contains correct arguments in terms of ratio or percentage increase. *Examples: Not reasonable. 10 is not a huge increase compared to a total of 500.* *No. According to the percentage, the increase is only about 2%.*
29	Other correct.

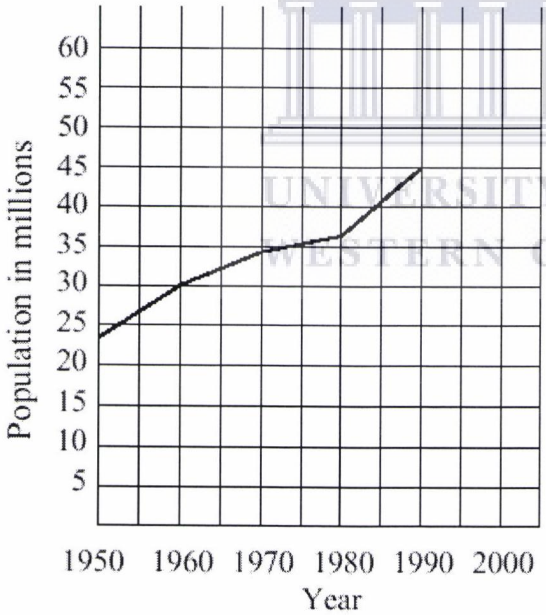
Continued Next Page

Partial Response	
10	NO. No explanation given.
11	NO. Focuses ONLY on an increase given by the exact number of robberies. *Examples: Not reasonable. It increased by 10 robberies.* *The word "huge" does not explain the reality of the increased number of robberies. The increase was only about 10 and I wouldn't call that "huge."*
12	NO. Focuses on the size of increase WITHOUT THE USE OF NUMBERS. *Example: Not reasonable. There has been an increase, but not a huge increase.*
13	NO. Indicates that the graph is misleading, but fails to point out the crucial features. *Examples: Not reasonable. The scale on the y-axis is misleading.* *No, it only looks like a huge amount because of huge bars and far apart distances.* *No, because it only appears that there was an increase of about 10 robberies. The T.V. guy misinterpreted the graph; he never read the axis.*
14	NO. Explanation consists of irrelevant arguments. *Example: No, because the previous year may have been just as high or higher but on the other hand it could be because the crime rate is becoming outrageous.*
19	Other partial.
Incorrect Response	
70	YES. No explanation given.
71	YES. Focuses on the increase in the exact number of robberies. *Examples: Reasonable interpretation. The increase is about 10.* *Yes, because as you can see from the graph, last year there were about 508 robberies and this year there were about 518. There were about 10 more robberies this year than last.*
72	YES. Focuses on the appearance of the graph.
73	Includes arguments, but no conclusions are drawn.
79	Other incorrect.
Nonresponse	
90	Crossed-out/erased, illegible, or impossible to interpret.
99	BLANK

Appendix 5

Educator:..
School:...

Assign possible clusters (possible contexts) to each item etc. finance, sport …

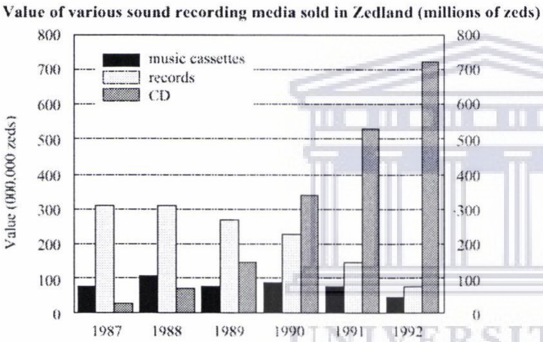
Exampler indicator item of TIMSS	**Cluster**
A3. Experts say that 25% of all serious bicycle accidents involve head injuries and that, of all head injuries, 80% are fatal. What percentage of all serious bicycle accidents involve fatal head injuries ? A. 16% B. 20% C. 55% D. 105%	
A4. If the population increases by the same rate from the year 1990 to the year 2000 as in the years from 1980 to 1990, approximately what is the expected population by the year 2000?  .... A. 47 million B. 50 million C. 53 million D. 58 million	

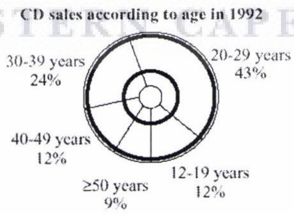
A5. A school club is planning a bus trip to the wildlife park. A bus which will hold up to 45 people will cost 600 centros (units of money) and admission cost 30 centros each.

If the cost of the trip, including bus and admission ticket, is set at 50 centros per person, what is the minimum number of people who must participate to ensure that these costs are covered?

A. 12
B. 20
C. 30
D. 45

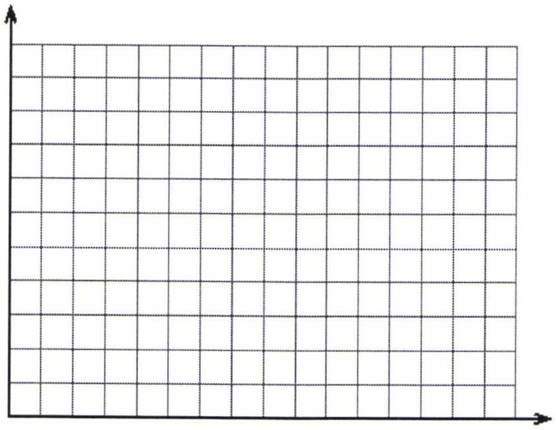
A8. The graphs give information about sales of CD's and other sound recording media in Zedland. Zeds are the monetary units used in Zedland. CD sales according to age in 1992.





With the aid of both graphs calculate how much money was spent by 12-19 year olds on CD's in 1992. Show your work.
(See appendix 4 for the graphs.)

A10. Sketch a graph which shows the relationship between the height of a person and his/her age from birth to 30 years. Be sure to label your graph, and include a realistic scale on the axis.



A12. The following two advertisements appeared in a newspaper in a country where the units of currency are zeds.

BUILDING A
Office space available

85 – 95 square meters
475 zeds per month

100 – 120 square meters
800 zeds per month

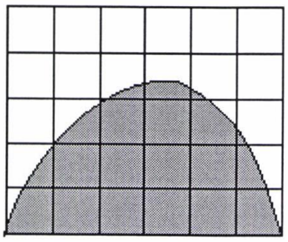
BUILDING B
Office space available

35 – 260 square meters
90 zeds per square meter per year

If a company is interested in renting an office of 110 square meters in that country for a year, at which office building, A or B, should they rent the office in order to get the lower price ?

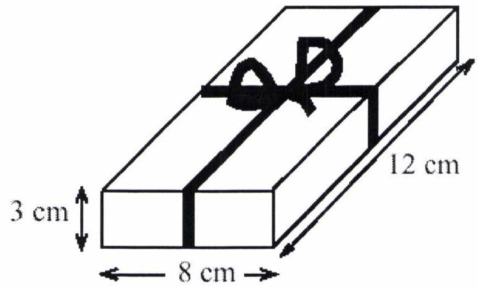
D6. A 45 000-liter water tank is to be filled at the rate of 220 liters per minute. Estimate, to the nearest half an hour, how long it will take to fill the tank.

A. 4 hours
B. 3 ½ hours
C. 3 hours
D. 2 ½ hours

D7. If there are 300 calories in 100 grams of a certain food, how many calories are there in a 30 gram portion of food ? A. 90 B. 100 C. 900 D. 1000 E. 9000	
D8. In a vineyard there are 210 rows of vines. Each row is 192 m long and plants are planted 4 m apart. On average, each plant produces 9 kg of grapes each season. The total amount of grapes produced by the vineyard each season. A. 10 000 kg B. 100 000 kg C. 400 000 kg D. 1 600 000 kg	
D9. A store is having a '20% off' sale. The normal price of a stereo system is $1250. What is the price of the <stereo system> after the 20% discount is applied? A. $1000 B. $1050 C. $1230 D. $1500	
D10. Each of the small squares in the figure is 1 square unit. Which is the best estimate of the area of the shaded region ? (See also appendix 4.)  A. 10 square units B. 12 square units C. 14 square units D. 16 square units E. 18 square units	

D11. Stu wants to wrap some ribbon around a box as shown and have 25 cm left to tie a bow. How long a piece of ribbon does he need?

A. 46 cm
B. 52 cm
C. 65 cm
D. 71 cm
E. 77 cm



D12. Brighto soap powder is packed in cube-shaped cartons. A carton measures 10 cm on each side.The company decides to increase the length of each edge of the carton by 10 per cent.
How much does the volume increase?

A. 10 cm^3
B. 21 cm^3
C. 100 cm^3
D. 331cm^3

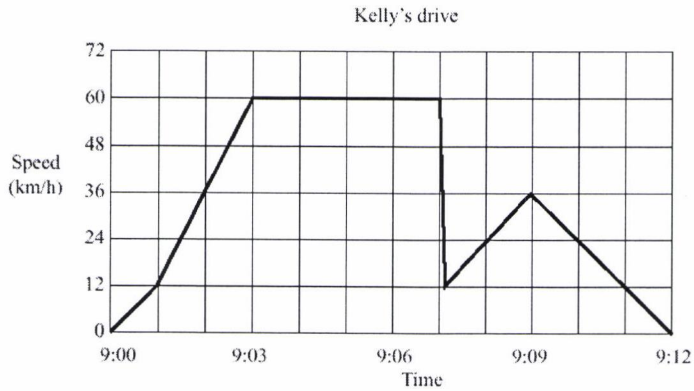
D13. In a school election with three candidates, Joe received 120 votes, Mary received 50 votes, and George received 30 votes.
What percentage of the total number of votes did Joe receive?

A. 60 %
B. 66 $^2/_3$ %
C. 80 %
D. 120 %

D14. From a batch of 3 000 light bulbs, 100 were selected at random and tested. If 5 of the light bulbs in the sample were found to be defective, how many defective light bulbs would be expected in the entire batch?

A. 15
B. 60
C. 150
D. 300
E. 600

D15. Kelly went for a drive in her car. During the drive, a cat ran in front of the car. Kelly slammed on the brakes and missed the cat.
Slightly shaken, Kelly decided to return home by a shorter route. The graph below is a record of the car's speed and time during the drive.



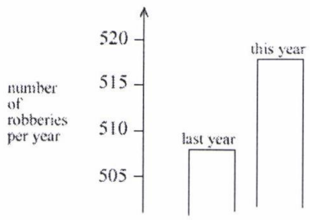
a) What was the maximum speed of the car during the drive.
b)What time was it when Kelly slammed on the brakes to avoid the cat?

D16. Teresa wants to record 5 songs on tape. The length of time each song plays for is shown in the table.

Song	Length of Time
1	2 minutes 41 seconds
2	3 minutes 10 seconds
3	2 minutes 51 seconds
4	3 minutes
5	3 minutes 32 seconds

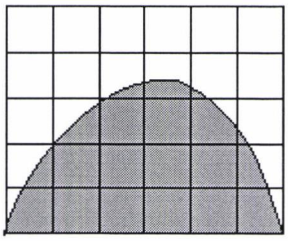
Estimate to the nearest minute the total time taken for all five songs to play and explain how this estimate was made.
Estimate:______________
Explain:

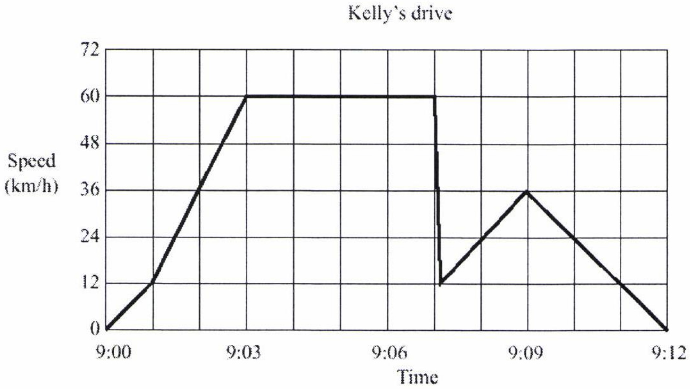
D17. A TV reporter showed this graph and said: "There's been a huge increase in the number of robberies this year."



Do you consider the reporter's statement to be a reasonable interpretation of the graph? Briefly explain.

Appendix 6: Clustering of TIMSS items

Exampler indicator item	**% Agreement**	**Number of Items**	**Cluster**
D10. Each of the small squares in the figure is 1 square unit. Which is the best estimate of the area of the shaded region ? (See also appendix 4.)  A. 10 square units B. 12 square units C. 14 square units D. 16 square units E. 18 square units	100%	1	Mathematics
		0	Mathematicians' Practices
A3. Experts say that 25% of all serious bicycle accidents involve head injuries and that, of all head injuries , 80% are fatal. What percentage of all serious bicycle accidents involve fatal head injuries ? A. 16% B. 20% C. 55% D. 105%	67%	1	Health
D14. From a batch of 3 000 light bulbs, 100 were selected at random and tested. If 5 of the light bulbs in the sample were found to be defective, how many defective light bulbs would be expected in the entire batch? F. 15 G. 60 H. 150 I. 300 J. 600	100%	3	Physical Science

D15. Kelly went for a drive in her car. During the drive, a cat ran in front of the car. Kelly slammed on the brakes and missed the cat. Slightly shaken, Kelly decided to return home by a shorter route. The graph below is a record of the car's speed and time during the drive.  a) What was the maximum speed of the car during the drive. b) What time was it when Kelly slammed on the brakes to avoid the cat? **D6.** A 45 000-liter water tank is to be filled at the rate of 220 liters per minute. Estimate, to the nearest half an hour, how long it will take to fill the tank. A. 4 hours B. 3 ½ hours C. 3 hours D. 2 ½ hours	67% 67%		
		0	Technology
D12. Brighto soap powder is packed in cube-shaped cartons. A carton measures 10 cm on each side. The company decides to increase the length of each edge of the carton by 10 per cent. How much does the volume increase? A. 10 cm^3 B. 21 cm^3 C. 100 cm^3 D. 331cm^3	50% (Others preferred different contexts etc. household and mathematics)	1	Production

<table>
<tr>
<td>A5. A school club is planning a bus trip to the wildlife park. A bus which will hold up to 45 people will cost 600 centros (units of money) and admission cost 30 centros each.

If the cost of the trip, including bus and admission ticket, is set at 50 centros per person, what is the minimum number of people who must participate to ensure that these costs are covered?
A. 12
B. 20
C. 30
D. 45</td>
<td>67%</td>
<td>4</td>
<td>Finance</td>
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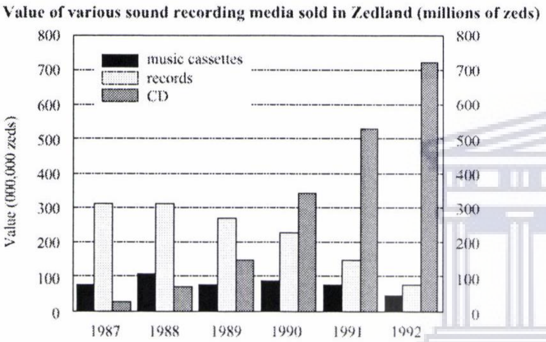
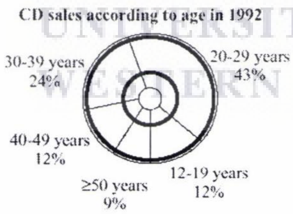
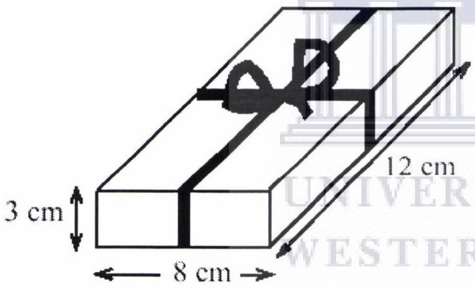
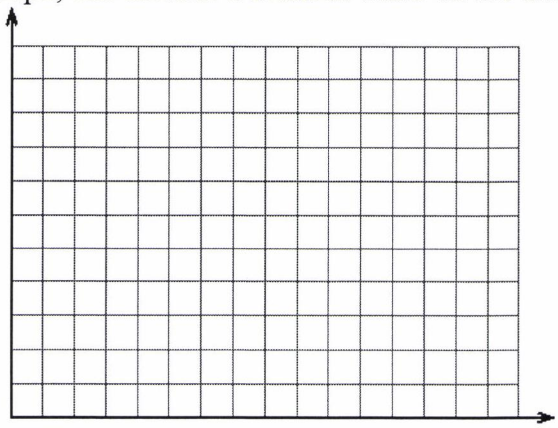
<td>A8. The graphs give information about sales of CD’s and other sound recording media in Zedland. Zeds are the monetary units used in Zedland. CD sales according to age in 1992.





With the aid of both graphs calculate how much money was spent by 12-19 year olds on CD’s in 1992. Show your work.
(See appendix 4 for the graphs.)</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D9. A store is having a ‘20% off’ sale. The normal price of a stereo system is $1250.
What is the price of the <stereo system> after the 20% discount is applied?

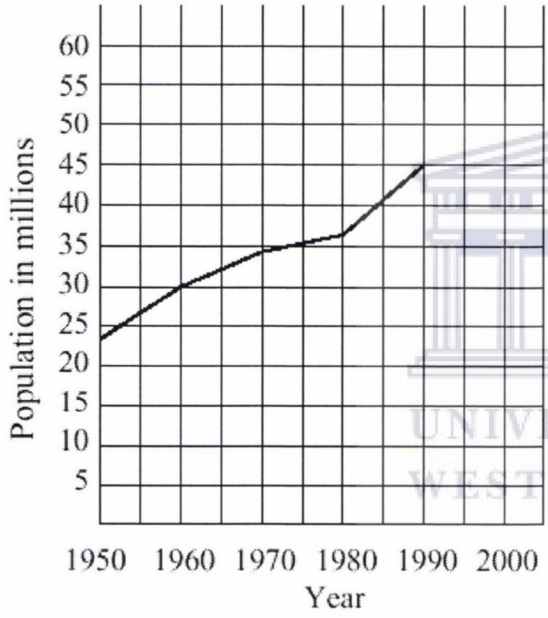
A. $1000
B. $1050
C. $1230
D. $1500</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</table>

A12. The following two advertisements appeared in a newspaper in a country where the units of currency are zeds. **BUILDING A** Office space available 85 – 95 square meters 475 zeds per month 100 – 120 square meters 800 zeds per month **BUILDING B** Office space available 35 – 260 square meters 90 zeds per square meter per year If a company is interested in renting an office of 110 square meters in that country for a year, at which office building, A or B, should they rent the office in order to get the lower price ?	100%		
D11. Stu wants to wrap some ribbon around a box as shown and have 25 cm left to tie a bow. How long a piece of ribbon does he need? A. 46 cm B. 52 cm C. 65 cm D. 71 cm A. 77 cm  	(A range of contexts were proposed- In the end no clear majority was evident therefore the item was regarded as a general one)	1	General
A10. Sketch a graph which shows the relationship between the height of a person and his/her age from birth to 30 years. Be sure to label your graph, and include a realistic scale on the axis. 	67%	3	Life Sciences

D7. If there are 300 calories in 100 grams of a certain food, how many calories are there in a 30 gram portion of food ? 67%

A. 90
B. 100
C. 900
D. 1000
E. 9000

A4. If the population increases by the same rate from the year 1990 to the year 2000 as in the years from 1980 to 1990, approximately what is the expected population by the year 2000? 67%



A. 47 million
B. 50 million
C. 53 million
D. 58 million

<table>
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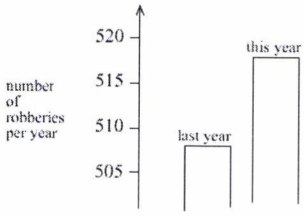
Do you consider the reporter‘s statement to be a reasonable interpretation of the graph? Briefly explain.</td><td>100%</td><td>1</td><td>Crime</td></tr>
<tr><td></td><td></td><td>0</td><td>Sport</td></tr>
<tr><td>D16. Teresa wants to record 5 songs on tape. The length of time each song plays for is shown in the table.
<table><tr><th>Song</th><th>Length of Time</th></tr><tr><td>1</td><td>2 minutes 41 seconds</td></tr><tr><td>2</td><td>3 minutes 10 seconds</td></tr><tr><td>3</td><td>2 minutes 51 seconds</td></tr><tr><td>4</td><td>3 minutes</td></tr><tr><td>5</td><td>3 minutes 32 seconds</td></tr></table>
Estimate to the nearest minute the total time taken for all five songs to play and explain how this estimate was made.
Estimate:______________
Explain:</td><td>100%</td><td>1</td><td>Youth Culture</td></tr>
<tr><td>D13. In a school election with three candidates, Joe received 120 votes, Mary received 50 votes, and George received 30 votes. What percentage of the total number of votes did Joe receive?
A. 60 %
B. $66\,^{2}/_{3}$ %
C. 80 %
D. 120 %</td><td>100%</td><td>1</td><td>Politics</td></tr>
<tr><td>D8. In a vineyard there are 210 rows of vines. Each row is 192 m long and plants are planted 4 m apart. On average, each plant produces 9 kg of grapes each season.
The total amount of grapes produced by the vineyard each season.
A. 10 000 kg
B. 100 000 kg
C. 400 000 kg
D. 1 600 000 kg</td><td>100%</td><td>1</td><td>Agriculture</td></tr>
</table>