A comparison between the contexts grade 10 learners prefer for Mathematical Literacy and those reflected in the PISA survey

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KEYWORDS

Mathematical Literacy

Contexts in Mathematics

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OECD

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TIMMS

Relevance of Mathematics

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ABSTRACT

A comparison between the contexts grade 10 learners prefer for Mathematical Literacy and those reflected in the PISA survey.

The 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 Organization for Economic Cooperation and Development's (0ECD) Programme for International Student Assessment (PISA). The most important findings of the study are that the grade 10 learners from low socio-economic environments regard the intra-mathematical clusters as the most favoured items. In the extra-mathematical cluster learners favoured technology and health. PISA designers favoured the mathematical cluster followed by physical science and the finance cluster. The context preferred by learners may differ from what designers of tests may perceive to be relevant or interesting and vice versa.

DECLARATION

I declare that *A comparison between the contexts Grade 10 learners prefer for Mathematical Literacy and those reflected in the OECD's PISA survey* is my 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 acknowledge as complete references.

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CHAPTER 1

INTRODUCTION

1.1 Background and Rationale

Internationally there is a thrust towards contextually-driven Mathematical Literacy (ML). This is borne out by the triennial survey called the Programme for International Student Assessment (PISA), which is conducted through the Organization for Economic Cooperation and Development (OECD). Implicitly, it is accepted that there is a link between student performance in mathematics, and the relevance of the problems to student's lives (Ensign, 1997). The relevance of the problems is achieved by means of the contexts in which the subject is tested. This study examines the contexts which South African students are interested in to deal with in Mathematics and how these preferred contexts relate to those appearing in PISA.

1.1.1 The OECD and PISA

The OECD is an organization that acts as a meeting ground for more than thirty countries which believe strongly in the free market system. OECD thus provides a forum for discussing issues and reaching agreements of which some are legally binding OECD (OECD, 2003).

PISA is an internationally standardized assessment method that was jointly developed by participating OECD countries and administered to 15-year-olds in educational programmes. It is in the form of a survey that was first implemented in 43 countries over two cycles. For the first cycle in 2000 there were 32 countries; 11 countries in 2002 and then in 42 countries in the second cycle. Its tests were typically administered to between 4 500 and 10 000 students in each country (OECD, 2003). The background of the PISA initiative can be seen from four points of reference: Content, Methods, Assessment Cycles and Outcomes.

1.1.1.1 Content

The OECD/PISA 2003 covers the domains of reading, Mathematical and Scientific Literacy although not so much in terms of mastering the school curriculum, but in terms of important knowledge and skills needed in adult life. In this study the above mention domains are referred to as contexts. The examination of cross-curriculum competencies continues to be an integral part of OECD/PISA through the assessment of a new domain of problem solving. Emphasis is mostly on the mastering of processes, the understanding of concepts and the ability to apply knowledge in various situations within each domain.

1.1.1.2 Methods

Paper-and-pencil tests are used, with assessments lasting a total of two hours for each student. Test items are a mixture of multiple-choice questions and free response questions, which require students to construct their own responses. The items are organized in the form of groups based on a passage setting derived out of a real-life situation. A total of about seven hours of test items is covered, with different students taking different combinations of the test items. Participating students are expected to answer a background questionnaire, which takes about 30 minutes to complete, providing information about themselves and their homes. Principals complete a questionnaire about their schools.

1.1.1.3 Assessment Cycle

The assessment system of the OECD/PISA takes place every three years: 2000, 2003 and 2006. Each of these cycles looks in depth at a "major" domain, to which two-thirds of testing time is devoted whereas, the other domains provide a summary profile of skills. Major domains were reading literacy in 2000, Mathematical Literacy in 2003 and Scientific Literacy in 2006.

1.1.1.4 Outcomes

A basic profile of knowledge and skills among 15-year-old students is one of the main outcomes. Contextual indicators relating results to student and school characteristics are the other main outcome. Trend indicators showing how results change over time are a derivative of the assessment system. A valuable knowledge base for policy analysis and research are also a critical outcome (OECD, 2003).

1.2 Motivation of the study

The frequent complaints about the quality of Mathematical Literacy and Mathematics in South Africa has become a hot area of focus in our search to try and establish the economical building blocks and work force that are needed in an increasingly technology-driven society. The Third International Mathematics and Science Study

(TIMMS) which is regarded by Howie & Hughes (1998) as the largest and most ambitious international study of Mathematics and Science achievement ever undertaken, with more than 500 00 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) has unearthed some discomforting results.

Students from other countries overall scores were significantly better than the scores of South African students. What was also evident were the low level of general numeracy and scientific understanding of South African students. Hence there is a question mark over our Mathematical Literacy (ML) curriculum's ability to prepare students on applying mathematical knowledge and skill to real life or to mathematical contextual situations. The relevance of South African's mathematical context is thus under scrutiny. Relevance in this case can refer to an empowering kind of Mathematics to the general public to enable them to cope with our demanding society.

Although South Africa does not participate in the OECD's PISA surveys (mainly due to the fact the South Africa are not included in the OECD) it is of still of great importance to understand what our learners contextual preferences are against those of PISA. The main difference between TIMSS and PISA, is that PISA is not a test that focuses on the "official" curricula of participating countries only. Therefore this study attempt to provide some points of reference in our quest to improve Mathematics in terms of its content as well as improving the utilization of its current contexts by making them more user-friendly and relevant than before.

1.2.1 Situation of the current curriculum

It is important to understand the current thinking in South African education in order to be able to assess the changes that have been made thus far. According to the National Department of Education's Policy Document (1997), outcomes-based education (OBE) was introduced as the underpinning of the new post apartheid curriculum. In a nutshell, OBE starts with the philosophy that all learners can learn and it is driven by the outcomes to be demonstrated by the learner at the end of the educational experience. From this starting point, OBE clearly defines the knowledge, understanding, skills and values that learners are to go through. This curriculum has been revised two times until 2006. It tries to reflect the background of all South Africans in all spheres of life, being political, social, historical or psychological.

The National Curriculum Statement (NCS) starts in grade one and consists of a General Education and Training (GET) band (Grades R-9) and a Further Education and Training (FET) band (Grades 10-12). Furthermore, a National Qualifications Framework (NQF) was developed to register all educational qualifications offered in South Africa.

According to the National Department of Education's (DoE,2004) the educational guidelines and policies of the country consist of the following major goals:

- To provide equal opportunity in terms of access, equity, relevance and continuity of education.
- To enhance the relevance and appropriateness of all curricula.
- To introduce relevant technology at all levels and in all areas of education.

- To enhance capacity building at the national level through the training of South African professionals and experts.

The National Committee on Further Education (1997) developed the founding framework for a post-apartheid FET curriculum. This Committee calls for the transformation of the education and training system so as to promote equity, redress, economic competiveness and quality learning in their report. There are also a calls for more inclusiveness in the curriculum. Although the above mention calls are written in a generalized manner and not only for one specific subject, one finds that the aims of the curriculum are relevant to most of Niss's (1996) exterior and interior aims.

1.2.2 The general aims of Mathematics

Niss (1996:32-33) claims that a vast majority of countries pursue the following exterior and interior 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 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 research attitudes, linguistic capacities, aesthetic experience and pleasure, etc;
- 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 analyze 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.

1.2.3 Niss and the South African situation

The move towards a context-driven and socially relevant curriculum is noticeable if one analyzes the aims carefully. Nearly all of the above mentioned aims are embedded in the NCS. The requirement, that all learners are compelled either to do Mathematics or Mathematical Literacy, coincides with the very first exterior aim highlighted by Niss (1996). Learners can choose in grade ten if they want to do either Mathematics or Mathematical Literacy. In the past, Mathematics was either offered on standard grade or higher grade level but was never compulsory.

On examining the stated aims of the new educational guidelines of South Africa, one can therefore clearly see congruence in terms of its stated goals to both the external and internal aims suggested by Niss. This study therefore leans heavily upon the ideas put forward by Niss (1996), since the emphasis placed on attaining equity in education, stimulating and emphasising interest in technology as well as the broader function that education is supposed to play, features prominently in both the goals of the Education department as well as Niss' aims.

It is within this context that the study is undertaken, to investigate to what extent, the assessment of South African learners correspond to the ideal of having contexts that learners are interested in contained in the assessment instruments.

1.3 Statement of the problem

1.3.1 Situation of the Current Curriculum

After the 1st democratic election in South Africa in 1994 a new curriculum was implemented. One of the requirements of the new curriculum is that all learners are compelled to either do Mathematics or Mathematical Literacy up to Grade 12. The White Paper on Education and Training in South Africa (1995) proposes the development of alternative curriculum based on principles of access, redress, equity, credibility, quality and efficiency. One therefore sees an educational policy which has aims in common with what Niss (1996) stated, i.e. 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 demographic society,.

Thus a dramatic shift towards more context-driven school Mathematics curriculum was needed. These shifts have been brought about because of the demand of the technological driven 21st century economies which need more higher levels of

Mathematical Literacy. With regards to Mathematical Literacy, which is a new subject in the FET-band, no claims can be made that this newly context-driven subject will contribute towards the alleviation of the difficulties learners used to experience with Mathematics.

1.4 Research questions

Barnes (2006:13) pointed out that all the stakeholders (curriculum planners, educators, parents and politicians) want the Mathematics curriculum to be relevant, therefore the focus question that needs to be answered must be: What contexts are contained in the PISA studies? When is school mathematics relevant? The main research question for this study is on how do the contexts that are appearing in PISA Mathematical Literacy instrument compare with the contexts grade 10 learners are interested in.

1.5 Organization of the study

This study is organized into five chapters. Chapter 1 deals with the introduction and background of the study. Chapter 2 discusses the literature review of the relevance of Mathematics, Mathematical Literacy, mathematical modelling and the OECD's Programme for International Student Assessment (PISA). Chapter 3 focuses on the research methodology for data collection, data presentation and analysis. Chapter 4 deals with the presentation and analysis of the collected data against research questions and finally, Chapter 5 focuses on the conclusions of the study and other recommendations that emerged from the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the idea of relevance and how it is linked to school Mathematics, Mathematical Literacy and mathematical modelling will be discussed. Over a long period of time, many people have pursued a theoretical construction to stimulate their debate about their search for the relevance of Mathematics. Some are just curious about the realities of the mathematical world. Others want to understand how applications of Mathematics in real-life situations came about and its role in the development of the society they live in. In the context of the developing world, Mathematics is seen as crucial in advancing technological and economic advancement. Hence it brings the notion of relevance to the fore.

2.2 Relevance of school Mathematics

The word relevance is described as "having direct bearing on the matter at hand, pertinent" in the Collins English dictionary (2004). Barnes (2006:13) argues that:

> ... if we use this definition, than relevant school mathematics would mean: mathematics that has a bearing on the sector/area which the mathematical problem/question relates to. It could also embrace the idea of what learners' interests are, particularly in relation to the subject of Mathematics.

Hence in terms of this definition, the relevance of school Mathematics would mean the level of interest a particular sector (curriculum, learning resources and test designers; parents; learners) has for issues and topics that should be taught in Mathematics and in school.

Ernest (1996) addresses the issue of relevance by positing that it is generally agreed Mathematics should aim to fulfil social needs, to provide the skills relevant for everyday life and work in industrial and developing societies, as well as form 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 of these needs. Politicians also display an interest in the relevance of Mathematics. Cameron Dugmore (2005), the Minister of Education of the Western Cape Province of South Africa, had the following to say about it:

> The government's position pertaining to relevance is to increase the number of learners to take Mathematics on the Higher Grade in order to live with the increasing demands of our increasingly globalised economy and technological nature of society.

In stating this, the politicians in South Africa highlighted the relevance of Mathematics as providing access into careers. This is understandable in the South African context because of a history of using Mathematics as a 'filter' in blocking access to further or additional learning.

The political rationale in stating this is that school mathematics could enhance a learners' possibility to obtain work, a bursary or a learnership. Mathematics is relevant because it can address the lack of sufficient skilled labour in the South African economy. The De Lange Commission (1996) foundational assumption was that education policies be directly linked to economic development, and that such policies should be accountable in terms of 'relevance' (Kallaway 1984:33). In this regard, restoring the harmony between the schooling system and the labour market became a principal aim. Thus the needs of the labour market dictate in more than many ways what is relevant or not to politicians.

According to Boaler (1993:14), there are two reasons for learning in contexts:

> … one concerning the motivation and interest of learners through an enriched and vivid curriculum, the other concerning the enhanced transfer of learning through a demonstration of the links between school and mathematics and real world problems.

Barnes (2006:15) argues that if, according to Romberg's (2001:5) attempt to address the issue of relevance, where he asserts that the emphasis should be on "mathematical knowledge put into functional use in a multitude of different situations and contexts in varied, reflective and insightful ways." then by implication it means society must be mathematically literate.

According to Barnes (2006:15):

> While literacy is the foundation of all learning, Mathematical Literacy would therefore be necessary if we are to understand fully the information that

surrounds us in modern society. A fundamental aim of any country is to prepare its citizens for the future to fulfil various jobs and functions within the society. It is therefore important that decisions are made by taking into account the relevant context under which the country's needs are fulfilled.

It is clear that one cannot divorce relevance of school Mathematics and Mathematical Literacy from each other and hence Mathematical Literacy is discussed in the next section.

2.3 Mathematical Literacy

Literacy of any type is often defined in similar terms, ultimately meaning "using printed and written information to function in society" (Krish and Jingeblut, 1986). Literacy thus broadly refers to the use of human language. People are classified as literate if they are able to read, write and listen, and also use a language in a variety of situations at hand. 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, this implies that students not only must learn the concepts and procedures of mathematics (its design features), but they must learn to use such ideals to solve non-routine problems and learn to mathematise a variety of situations (its social functions). This notion can be regarded as Mathematical Literacy.

Furthermore in this regard, Snyders (2006:12) concurs that:

> Generally to be literate means to be competent, to have the appropriate skills to cope and make judgements pertaining to the issue at hand. In Snyders (2006) 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, so as to use them to their benefit.

Snyders (2006:12) believes that in this sense one can thus describe a person as literate or not.

There are similarities in both Romberg and Snyders observations and definitions of a literate person and their usage of Mathematics to be found in how PISA/OECD (2003: 24) regards Mathematical Literacy:

> Mathematical Literacy is an individual's capacity to identify, to understand and to engage in Mathematics and make well founded judgements about the role that Mathematics plays, as needed by an individual's current and future private life, occupational life, social life with peers and relatives, and life as a constructive concerned and relative citizen.

It seems in many cases as if quantitative literacy, numeracy and Mathematical Literacy are regarded as equivalent and similar terms, though others try to discriminate between them so as to fulfil a certain purpose (Hawkins 1990; Steen 1990; Cooper 1991; Steen 1991; Usiskun 1997; Ball and Stacey 2001; Romberg 2001).

According to Doyle (1994:23) Mathematical Literacy is driven by real-life contexts and should take a high priority in the learning and teaching of Mathematics. He also asserts that teachers of Mathematics need to change their teaching strategies to accommodate the interests of their learners.

Jablonka (2003:75 – 102) is of the opinion that numeracy refers to the numerical nature of Mathematics whereas Mathematical Literacy entails a broader approach of Mathematics with the understanding that the target audience is a group of individuals with a sound educational background. Steen (1990:1) regards numeracy as important for a nation expecting to compete in the global economy fuelled by information technology. According to Steen (1994), numeracy is a mathematical skill that enables an individual to cope with the practical demands of everyday life.

Evans (2000) defined 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.

Julie and Mbekwa (2005) stated that the advent and incorporation of Mathematical Literacy as a distinct subject has further justified the use of contexts for mathematical activity in schools.

> This is because Mathematical Literacy deals primarily with context. Mathematical Literacy falls within the realm of "applications and modelling of Mathematics" viewed in a comprehensive sense as both "'modelling [which]

focuses on the direction reality – mathematics" and '" application' [which focuses on the opposite direction mathematics – reality" (International Programme Committee for ICMI Study, 2002:14) and in this configuration the primacy of context is obvious.

Context however, can become a robust, debatable and contentious issue in a land like South Africa, with its huge diversity in languages, religions and cultures. Some learners might find the context of a particular open-ended mathematical activity unsuitable and inappropriate as opposed to others.

Keeping this in mind, attention should be given to the opinion of the National Council of Teachers of Mathematics (NCTM, 1989:5) that Mathematical Literacy should focus on the following five processes:

- Valuing mathematics
- Becoming confident in one's ability to do mathematics
- Becoming problem solvers
- Communicating mathematically
- Reasoning mathematically

Furthermore, Jablonka (2003) classifies different approaches to Mathematical Literacy into five categories. These approaches will be directly linked with the goals that are pursued. She categorizes mathematical literacy into the following approaches:

- Mathematical literacy for developing human capital
- Mathematical literacy for social change
- Mathematical literacy for environmental awareness
- Mathematical literacy for evaluating mathematics
- Mathematical literacy for cultural identity

2.4 Mathematical Literacy in the Mathematics curriculum in South Africa

The modern South African society has changed rapidly since the 1994 democracy elections. It has become more information-driven and has created new societal goals. Thus with a global demand, a transformation in the education system was constructed to address the inequalities of the past. A clear distinction is made between Mathematics and Mathematical Literacy in the Revised National Curriculum Statement that became the National Curriculum Statement (NCS) in 2005.

The NCS of South Africa states the purpose of Mathematical Literacy as follows (DoE 2005:7):

- Mathematical Literacy provides learners with opportunities to engage with real-life problems in different contexts and so consolidate and extend basic mathematical skills.

- Mathematical Literacy will equip learners with the ability to understand mathematical terminology and make sense of numerical and spatial information communicated in tables, graphs, diagrams and texts.

- Mathematical Literacy will, furthermore, develop the use of basic mathematical skills in critically analysing situations and creatively solving everyday problems.

- Mathematical Literacy enables the learner to become a self-managing person, a contributing worker and a participating citizen in a developing democracy.

  a) A self-managing person must be equipped with Mathematical Literacy for everyday life including financial issues, and the efficient use or rationing and proportioning in cooking and use of medicine.

  b) A contributing worker in the workplace requires the use of fundamental numerical and spatial skills to deal with work-related formulas, read statistical charts, deal with schedules and understand instructions involving numerical components.

  c) A participating citizen in a developing democracy must have [the] ability to understand mathematical arguments and statistics presented in the media and other platforms. In the information age, the power of numbers and mathematical ways of thinking often shape policy.

In summary, Mathematical Literacy aims to develop four important abilities:

i) The ability to use basic Mathematics to solve problems encountered in everyday life and in work situations.

ii) The ability to understand information represented in mathematical ways.

iii) The ability to engage critically with mathematically based arguments encountered in daily life.

iv) The ability to communicate mathematically.

(Department of Education, 2005:8)

Mathematical Literacy and Numeracy are used as different subjects in different phases of the schooling system in South Africa. 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 in the following manner:

> 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) in the following statement:

> Mathematical Literacy provides learners with an awareness and understanding of the role that Mathematics has in the modern world. Mathematical Literacy is 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.

It is not easy to distinguish between Mathematics and Mathematical Literacy because they are so closely linked to each other. However a closer look at the learning outcomes of each discipline as been described in the respective curriculum statements (2003a:9), as displayed in table 2.1, which can shed some light onto the comparison and differences between them.

Table 2.1: 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.

Just by analysing the first two learning outcomes, it is evident that Mathematical Literacy is to a large extent context driven, whilst the teaching and learning of Mathematics is not. Although the learning outcomes for Mathematics and Mathematical Literacy are more or less the same and in some instances overlap, the difference is in the focus-solution of contextually-driven situations in Mathematical Literacy and the structure of Mathematics in Mathematics.

Julie and Mbekwa (2005) stated that the use of contexts in Mathematical Literacy, as embedded in mathematical modelling and applications, differs from the use of context for the induction into pure Mathematics. In distinguishing between the differences and overlaps of Mathematics and Mathematical Literacy it leads to the question of what the role of application and modelling is. Therefore my focus will now be to shift to mathematical modelling.

2.5 Mathematical modelling

The shift from pure Mathematics to the developing of mathematical representation for situations from outside of Mathematics is driven by a process of mathematical modelling. Mathematical Literacy is confronted with dealing with extra-mathematical situations and using 'mathematising' (requires discussion, rethinking and different explorations and investigations) to come up with the best possible answer. Higher cognitive activities such as interpretation, analysis and synthesis come to the fore.

Hendricks (2006:14) asserted that it is important that Mathematics educators realise that learning to apply Mathematics is a very different activity from learning Mathematics. In his view, applying Mathematics and mathematising requires a completely different skill than learning Mathematics.

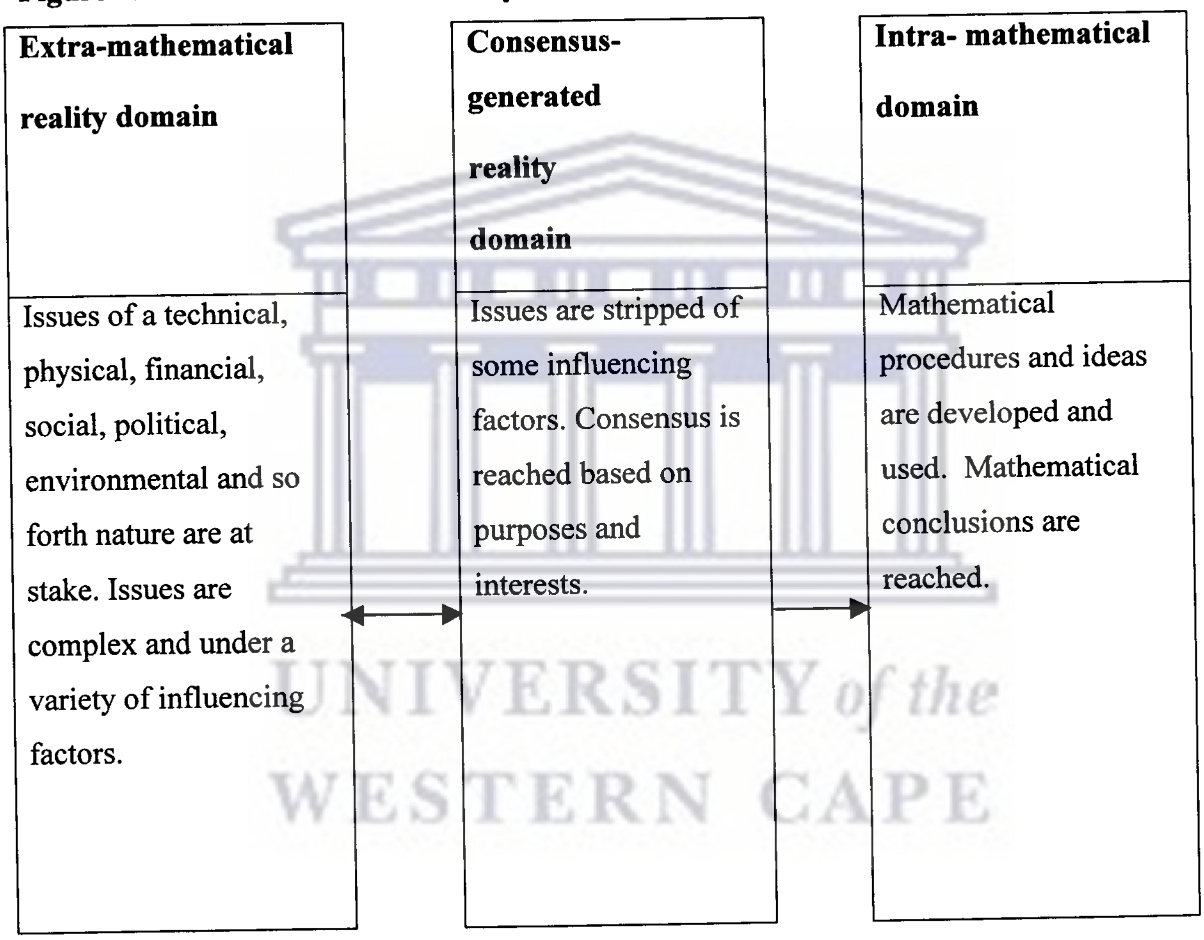
So what is mathematical modelling? According to Aris (1979:1), a mathematical model is any complete and consistent set of mathematical equations which is thought to correspond with some or other entity, its prototype "Prototype" in this sense implies any physical or conceptual entity. It may even represent another mathematical model. Mathematical modelling represents, therefore, the process of using various mathematical structures – graphs, equations, diagrams, scatterplots, etc. – to represent real world situations.

According to Davis and Hersh (1986), three types of models can be classified on the basis of the purpose they serve:

- Descriptive models: constructed to describe an existing reality as accurately as possible.
- Predictive models: constructed to describe a section of reality, but in this case it is in a state that does not yet exist.
- Prescriptive models: intended to give guidelines for the construction of a section of reality.

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).

Figure 2.1: The translation of reality issues through different domains



Julie (2004) pointed out that the reality situation is transformed through consensus where interests and purpose are settled and the resulting mathematisation relates to this consensus – generated reality.

Snyders (2006:26) noted that these three processes of mathematical modelling are complementary to each other to build up a more comprehensive description of a complex process regarding mathematical modelling. In seeing and experiencing how mathematical devices control, organise, predict and manipulate nature and social life, and have penetrated every part of reality, Snyders (2006:26) confirms that "The applications of and the modelling in Mathematics is one of the ways to reflect this inter-relationship between reality and Mathematics."

Before the introduction of the National Curriculum Statement, many curriculum developers, educationists and mathematical teachers lobbied for the inclusion of mathematical modelling in the school mathematics curriculum. One of the reasons for this was to get learners to actively apply mathematical skills and in doing so, engage with their reality and surroundings mathematically. Blum and Niss (1991) identified five reasons why modelling and applications should be included in the school curriculum. The reasons are:

- Formative
- Critical experience
- Utility
- The picture of mathematics and
- Promoting mathematics learning.

In South Africa the Department of Education (DoE) introduced and implemented mathematical modelling in mathematical literacy for grade 10 in 2006, for grade 11 in 2007 and for grade 12 in 2008.

The Revised National Curriculum Statement (2002:9) states the following about mathematics modelling:

> Mathematical modelling provides learners with a powerful and versatile means of mathematically analysing and describing their world. Mathematical modelling involves identifying and selecting relevant features of real-world situations, representing those features in mathematical representations, quantitatively and qualitatively analysing the model and the characteristics of the situation, and considers the accuracy and limitations of the mathematical model. Mathematical modelling allows learners to deepen their understanding of Mathematics while expanding their repertoire of mathematical tools for solving real-world problems.

In 2004 the DoE in its Mathematical Learning Programmes Guidelines (2004) 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":

- 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.

- 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).

- 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).(National Education Department, 2003:84 – 85).

In concluding this section of mathematical modelling, it would be useful to differentiate between the applications of Mathematics and mathematical modelling as explained by Blum and Niss (1991:38):

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

Barnes (2006:24) asserted that the use of Mathematics to solve "real" world problems is often called applying Mathematics, and a "real" world problem which can be solved by using or applying Mathematics is called an application of Mathematics. The idea of "applying" is sometimes used to connect the "real" world and Mathematics.

2.6 Conclusion

Contextual situations could provide the necessary relevance to Mathematical Literacy enhancement. Mathematical Literacy can play a crucial role in our society in that it could provide citizens with the tools to mathematising of real life situations and thus construct and improve their own mathematical modelling. If relevance is perceived to be of interest for the learners, their preferences should also taken into consideration as far as contextual situations are concerned. It would also be worthwhile to compare these preferences with the contexts the PISA-designers favoured. In the following chapter the research methodology will be dealt with.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with the research methodology employed in this comparative study of the contextual interests Grade 10 learners prefer for Mathematical Literacy and those reflected in the OECD's Programme for International Student Assessment (PISA) survey. Included in this section, are the research method, method of data collection and the pilot study that was conducted.

3.2 Research Methods

According to Gay (1981:143), a research method to a great extent determines specific procedures of a particular research study. Gay also explains that each research method has a unique purpose, thereby implying that the application of each method would entail a unique set of procedures and concerns. However all research studies have common procedures for example; there are always some types of data collection and analysis.

3.2.1 Descriptive research method

As explained by Gay (1981:153), descriptive research involves collecting data in order to test hypotheses or to answer questions concerning current status of the object of study. The research method used in this study is survey research. This method is the most commonly used descriptive research approach in social sciences and is useful for investigating a variety of educational problems. Descriptive studies are concerned with the assessment of attitudes, opinions, statements, demographic information, conditions, phenomena and procedures. Descriptive data are usually collected through questionnaires, interviews or observations.

Since this study is concerned with the analysis of Grade 10 learners' preferences for Mathematical Literacy and those reflected in the PISA survey, it is a descriptive study.

3.2.2 Quantitative research method

Durrheim & Terblanche (1999:42) pointed out that quantitative researchers do collect data in the form of numbers and then use statistical types of data analysis. Coolican (1990:12) defined quantification as a process of measuring on some numerical basis. In his view, quantitative methods involve emphasizing meanings, experiences and so on. As stated by Mori (2002:1), quantitative research incorporates statistical elements designed to quantify the extent to which a target group is aware of or is inclined to behave in a certain way.

Features of quantitative research method as compared to a qualitative research method as given by Miles and Huberman (1994) are indicated in Table 3.1 below.

Table 3.1: Features of quantitative and qualitative research (Miles and Huberman, 1994:40)

Qualitative	Quantitative
"All research ultimately has a qualitative grounding" (Donald Campbell)	"There's no such thing as qualitative data. Everything is either 1 or 0" (Fred Kerling)
The aim of qualitative analysis is a complete and detailed description.	In quantitative research we classify features, count them, and construct statistical models in an attempt to explain what is observed.
The method recommended during the earlier phases of research projects.	The method recommended during the latter phases of research projects.
Researcher may only know roughly in advance on what he/she is looking for.	Researcher clearly knows clearly in advance on what he/she is looking for.
The design emerges as the study unfolds.	All aspects of the study are carefully designed before data is collected.
The researcher is the data gathering instrument.	The researcher uses tools, such as questionnaires or equipment to collect numerical data.
Data is in the form of words, pictures or objects.	Data is in the form of numbers and statistics.
Qualitative data is more 'rich', time consuming, and less enabling to be generalized.	Quantitative data is more efficient, and enabling to test hypotheses, but may miss contextual detail.
The researcher tends to become subjectively immersed in the subject matter.	The researcher tends to remain objectively separated from the subject matter.

3.3 Methods of data collection

According to Durrheim (1999:47), positivist research is one that values objectivity usually in the form of quantitative measurements. Such research can be used to measure the responses of large samples of people and thus facilitating generalization, group comparisons and statistical analysis. Gay (1981:155) defines a survey as an attempt to collect data from members of a population in order to determine the current status of that population on an issue. Since this study is also concerned with the current status of learners' preferred context to be dealt with in Mathematical literacy, a survey-type research was used to assess these preferences.

3.3.1 Research instruments

Different types of research instruments are used by a researcher to collect data for his/her study. Wiersma (1980:141) categorized data collection techniques into three areas: the personal interview, the written questionnaire and the controlled observation. According to Van Vuuren, D., Maree, D. & De Beer, A.S. (1998), some of the instrumentation techniques that can be used to get the required information from the sample include personal interviews, telephone interviews, mail questionnaires and daily interviews. In this case, the study was designed to use a questionnaire as the technique of collecting data for quantitative analysis. Van Vuuren et al (1998) stress further how it is imperative that the quality of a research is not compromised by either poor measures (weak questionnaires) or by using inappropriate data-gathering techniques.

Furthermore, both Van Vuuren et al and Wiersma stated that the principles of questionnaire construction are the same for developing any measurement instrument, and these are reliability and validity.

Malaka (1995) used four steps in his study on teachers to demonstrate the basic steps that need to be followed as well as those issues to consider when developing questionnaires. The first step is to clarify the reason for the study, the second step is to determine the information required from the respondents (in this studies case, learners). The third step is to list down all research questions that one wants to be answered in the questionnaire and the last step is to identify any additional (demographic) information required to address the research questions. This study used these four initial steps to plan and develop the questionnaires.

Julie and Mbekwa (2005) state that the survey instrument for this study was developed around some identified topics or clusters. These clusters had been identified by mathematics educators from South Africa, Zimbabwe, Uganda, Eritria and Norway. A total of thirteen clusters (including two intra-mathematical ones) evolved through this identification process. The identification of the first eleven extra-mathematical clusters was in a major way outlined in some modules and learning materials developed by the Consortium for Mathematics and its Applications (Garfunkel, 2004). Such outlining ensured compliance of items with the possible mathematical treatments of each cluster which were developed as indicators of the identified clusters. For example, the Mathematics related to the item; “Mathematics involved in making pension and retirement schemes," is comprehensively dealt with in a UMAP module by Ng (1987). Some clusters and the numbers of items in a cluster and an exemplary item for each cluster are shown in table 3.2.

Table 3.2: Representation of some Intra-mathematical and Extra-mathematical clusters used in this study (See also appendix 2)

Clusters	Number of Items	Exemplar Indicator Item
Mathematics	6	Mathematics that will help a learner to do it at universities and technikons
Mathematicians' Practices	5	How mathematicians make their discoveries
Health	5	Mathematics that can be 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 an individual's favourite sport
Youth Culture	5	Mathematics linked to South African pop music
Politics	4	Mathematics used by political parties for election purposes
Agriculture	4	Mathematics used to work out the amount of fertilizer needed to grow a certain crop

This study essentially dealt with the issues and situations that learners would prefer to deal with in Mathematics and those reflected in the PISA survey. The method of clustering, numbering of items per cluster and exemplar item led to the Relevance of School Mathematics Education (ROSME) instrument.

The questionnaire was of the closed-response type. This is the same to which Kanjee (1999) refers to as scaled questions. According to Kanjee (1999:296), scaled questions consist of statements or questions, followed by a rating scale where respondents indicate the degree to which they agree or disagree with the item. Kanjee (1999:296) also asserts that scaled questions are useful for measuring attitudes and personality as they can capture subtle gradations of opinion or perception. In this study a Likert scale format was used. The responses ranged from: 1 to 4 (1= Strongly disagree; 2= Disagree; 3= Agree and 4= Strongly agree). The advantage of this format is that the respondent is not limited to a choice of possible answers as listed but can also leave it blank.

A total of three hundred and ninety one (391) questionnaires were distributed for completion among grade tens in the various regions (see Table 3.7) and were all collected back at the end of the exercise. The questionnaires were drafted in English and translated into Afrikaans.

3.3.2 The population and sample for this study

Participants in this study were Grade 10 learners from schools in the peri-urban and urban areas of Western Cape (see Table 3.3). All schools served learners from low socio-economic status environments.

Table 3.3: Location of schools where the research survey was conducted

Region of schools	Urban	Peri-urban
District	Cape Peninsula	West Coast, Boland, Southern Cape, Klein Karoo

In each school one grade 10 class was randomly selected to complete the questionnaire. The demographic information is given in tables 3.4 to 3.7 below.

Table 3.4: Data collected based on age of learners

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 3.5: Data collected based on gender of learners

	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 3.6: Data collected based on the primary language of the learners

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

Table 3.7: Data collected based on the region in which the learners' school was situated

	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**	

3.4 The pilot study

As pointed out by Wiersma (1980:151), before preparing the final form of a questionnaire, the items should be tried out with a small group as a pilot run. The group need not to be a random sample of prospective respondent, but the members of the group should be familiar with the variable under study and should be in a position to make valid judgments about the items. Furthermore, he states that the results of the pilot run should identify misunderstandings, ambiguities and useless or inadequate items. The same sentiments were also asserted by Bahta (2003:40). The instrument used in this, the pilot study, is described by Julie and Mbekwa (2005).

3.4.1 PISA-Mathematical items (Population 3)

The PISA-Mathematical Literacy Achievement tests for population 3 (students at age 15) (2003; appendix 4) was also used as another research instrument in this particular study. The PISA items were given to five Mathematics teachers and one subject advisor in non-cluster form (see appendix 5). The teachers and the advisor were then requested to provide a general category name for each item. A cluster classification of the items, based on majority agreement, was then constructed from the provided categories. A percentage agreement for the items was also included to ensure reliability and validity of the classification of the PISA items (see appendix 6).

To identify the contexts that the developers of the PISA instrument preferred to use as contexts, the frequencies of items in a certain category were taken as a benchmark for the designers' preference. If there were 5 items under technology and 2 for agriculture, it was then accepted that the test designers gave higher preference to technology, over agriculture, as an extra-mathematical item. This data was used for comparison with the data of a ROSME instrument.

3.4.2 Data analysis procedure

Non-parametric procedures were used to analyze the data. Durrheim (1999:118) states that non-parametric statistical techniques focus on the order or ranking of scores (or merely the classificatory function of members) and ignore the numerical properties of numbers such as interval and ratio scales. Furthermore, Durrheim (1999:118-119) argues that the difference between non-parametric and parametric procedures can be found in the way the mean and median are determined. Whereas the mean is a parametric estimate of central tendency because it takes the numerical value of scores into consideration by using mathematical operations; the median however, is determined only by ordering scores. Durrheim (1999:119) concluded that since only interval and ratio scales of measurement allow mathematical operations, parametric statistics are only appropriate for such data. Non-parametric procedures were thus developed to deal with ordinal data.

Non-parametric procedures are sometimes called distribution free statistics because they do not require that the data fit a normal distribution. The non-parametric tests require less restrictive assumptions about the data and they also allow for the analysis of categorical as well as ranked data.

Durrheim (1999:92) provided a definition for ordinal measure in that it measures categories that are both different from each other, and ranked/ordered in terms of an attribute. The Kendall W-test was chosen to provide a mean ranking value of each item. The Kendall W test is used for expressing interrater agreement among independent judges who are rating (ranking) the same data. The Kendall W was used to rank the

ROSME items (ordinal data) utilizing the Statistical Programme for Social Sciences (SPSS) version 13.

3.4.3 Issues on reliability and validity

Durrheim (1999:46-63) stated that reliable measures are stable in the sense that they consistently give the same information repeatedly when used under similar conditions. Therefore, reliability is the degree to which the results are repeatable. This applies to subjects' scores on measures (measurement reliability) and to the outcomes of the study as a whole. In relation to validity, Durrheim (1999:46-63) defined it as the extent to which the operational definition is a true reflection of the conceptual definition. Therefore, validity refers to the degree of credibility to which the research conclusions are sound.

The research instrument (learners' questionnaire) was a product of regular changes and improvement by the researchers over a period of three years. The researchers met regularly to discuss and improve the questionnaire and at these meetings through competitive argumentation and judgments a well thought-through learner's questionnaire was constructed. The categorization of items also went through a similar process.

The researchers in most cases conducted the data collection themselves, whereas at some instances because of time constraints and other logistical problems, the Mathematics teachers had to be assigned to do and complete the task. The learner's questionnaires took on average, an hour to complete. In most cases the researchers were always on the site to give some guidance and clarity on each item, thus reducing the levels of uncertainty and lack of understanding in the whole exercise. The learner's questionnaire was never posted to/from the schools but the researchers instead had to physically collect and be with their questionnaires all the time. This data collection procedure ensured the fidelity of the data obtained.

3.5 Conclusion

This chapter dealt with the research methodology employed in this study. It focused on the research methods, data collection techniques, methods of data collection and methods of data analysis. The data collection instrument was the questionnaire; the method of data collection was the survey and finally the data was analysis technique for the questionnaire was descriptive. The technique used to identify the clusters from the PISA instrument was interrater identification and agreement. In the following chapter the findings of the study will be discussed.

CHAPTER 4

FINDINGS

4.1 Introduction

This chapter deals with the findings related to the ROSME instrument. The clusters as well as the analysis of the individual items are focussed on. The findings from the analysis of the PISA instrument are discussed according to clusters. A comparison is then drawn between the data of these two instruments.

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, followed by mathematicians practices (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 forming the mathematics cluster (See also appendix 2 for the other clusters) are given. The cluster means 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

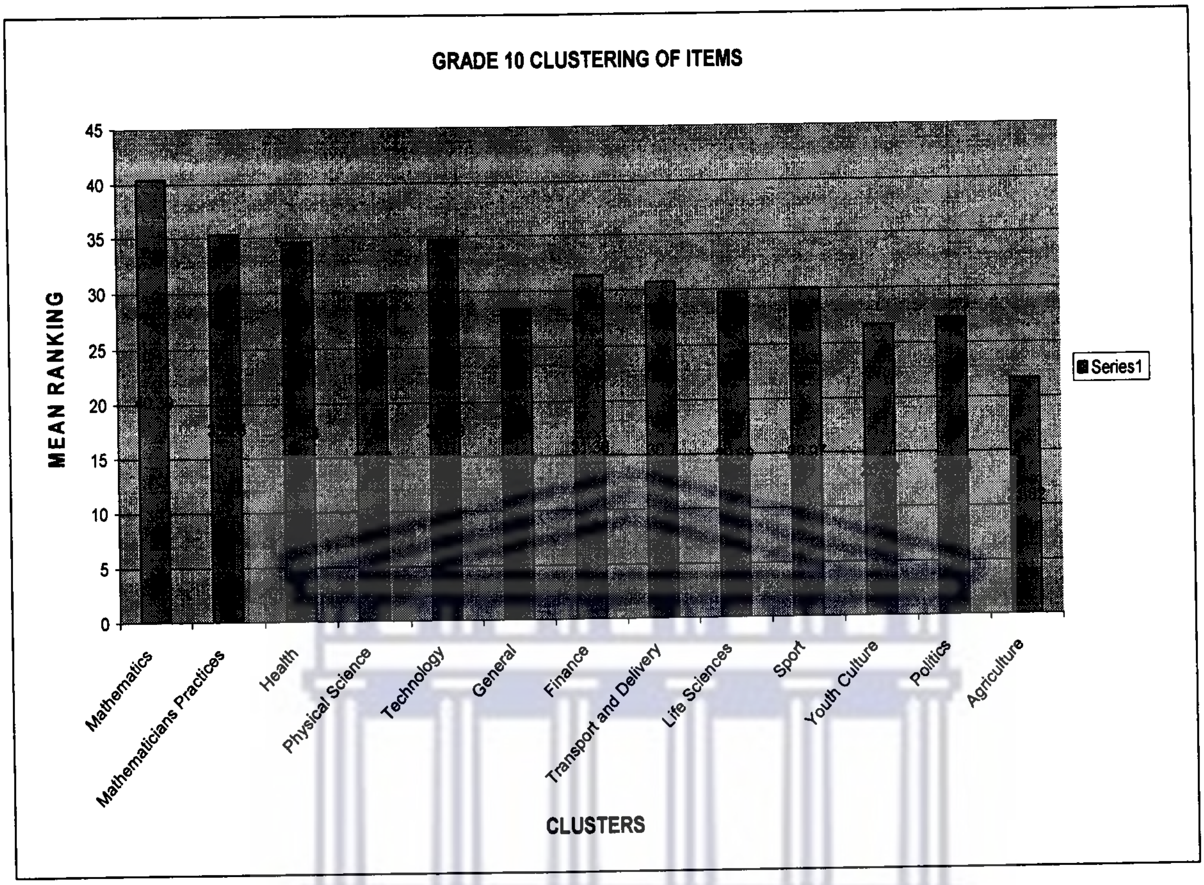


Table 4.1: Mathematics Cluster: Individual Ranked Items

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

What it shows is 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 ten 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 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 are the mechanism that is mostly used for the withdrawal of salaries. Interest in the mathematical, inner workings of these modern 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 PlayStations 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 also 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 extensive coverage in terms of educating people about HIV/AIDS and ways to try and prevent people from contracting HIV/AIDS, grade ten learners prefer to learn about Mathematics to prescribe the amount of medicine a sick person must take (table

4.3). Although this is not one of the core aims/objectives of this research, an answer to the following question can also be suggested: 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? However, since this study did not track learners' reasons for choosing a particular item, the researcher will not elaborate this issue. Although the NCS urges 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 and Tuberculosis
	27.93	Mathematics involved in determining levels of pollution

Analysing the ten highest-ranked individual extra-mathematical items that these grade ten's favour besides the technology and the health cluster item "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 caring element not only for themselves, but also for the fellow community members, are prominent. A camaraderie, a sharing and caring culture is prevalent in low socio-economic communities.

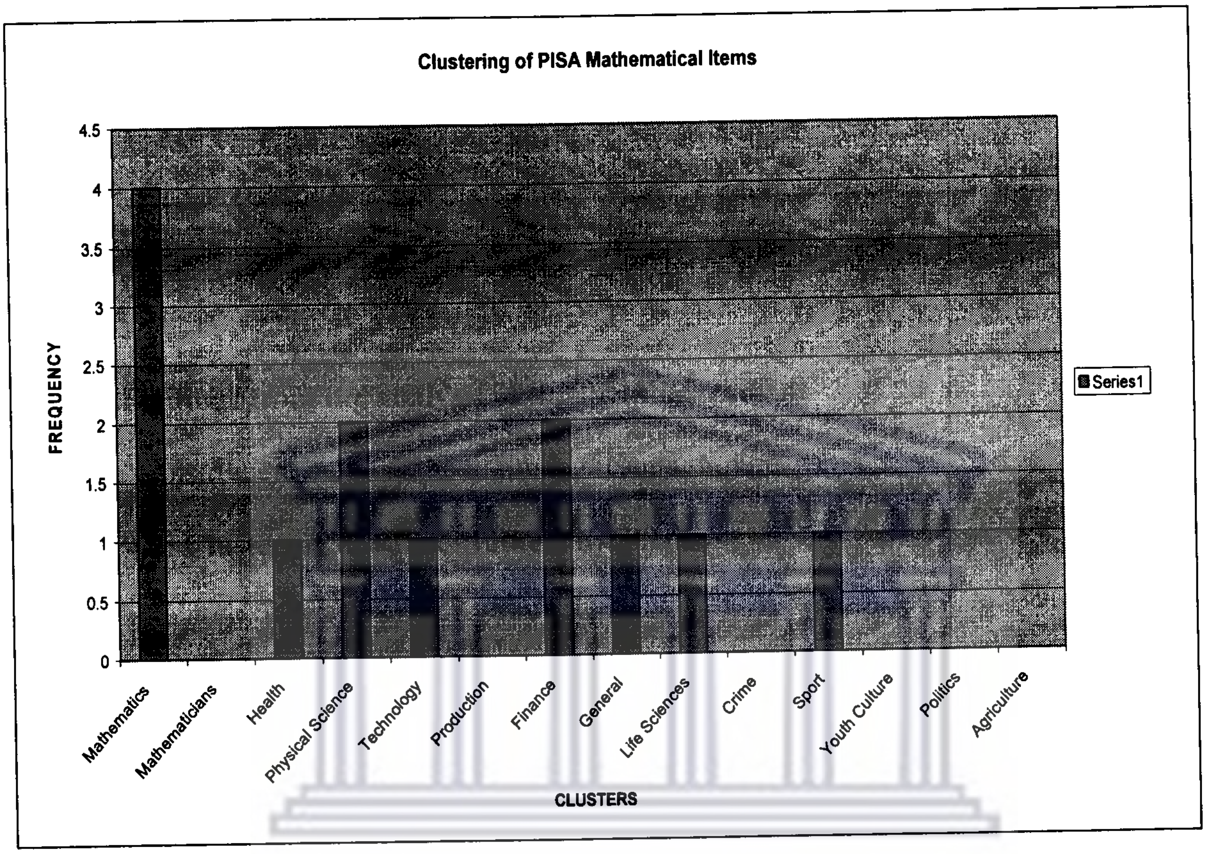
Table 4.4: Highest Ranked Individual Items: Extra-Mathematical

10 highest-ranked extra-mathematical items	Items	Mean Rank
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, cell phones 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

4.3 Findings from the analysis of the PISA instrument

The PISA instrument delivers the following results (Figure 4.2):

Figure 4.2: Clustering of PISA Mathematical Items



Designers of the PISA mathematical test items place a high premium on the mathematics cluster. This is followed by the physical science and finance cluster. This can partly be due to the fact that these items can be related to other school subjects or that the designers do not perceive contexts related to production, mathematician's practices, crime, youth culture, politics and agriculture, as important as the physical science and financial ones. Some categories that featured with PISA with a low occurrence are health, technology, sport and life sciences. As the youth of today are highly embedded in the everyday use of technological devices, for example MP3 players, cell phones, etc. it is almost contradictory that such a low occurrence in technology and no context of youth culture were covered by the PISA survey.

4.4 Comparison of ROSME – and PISA findings

The high emphasis on the pure mathematical context in PISA is in agreement with learners' ranking in this cluster as their most preferred.

If one compares the extra-mathematical clusters there are differences and overlaps in the ROSME and PISA findings. I shall concentrate on the top and lowest favoured clusters of both instruments.

The two top extra-mathematical clusters favoured by designers of the PISA mathematical items are the financial and physical science clusters. The financial cluster of ROSME is the third highest extra-mathematical cluster which shows that the PISA survey was in line with learners' preferences. This can be a result of an ongoing trend internationally to apply mathematics to financial issues in an effort to increase the educational awareness of money matters in daily life situations.

The extra-mathematical cluster that most grade ten learners of ROSME favoured is the one of technology. In comparison to the PISA questionnaire, little emphasis was put on technology. It is strange because most of the OECD countries that participate in PISA are first world countries which have strong technology-driven economies. There is not much evidence on the integration of learning areas i.e.: Mathematics with Geography in the PISA design to be found.

However when you consider that the PISA designers did not give any attention to youth culture, and combined with the low ranking of technology contextual items it raises, the question of whether the PISA designers paid sufficient attention to current interests of young people.

With the huge media coverage and ongoing HIV/AIDS campaigns in South Africa, it is no wonder that the health cluster also receive a higher interest as shown by the ROSME findings. This is in contrast to the PISA findings in which little attention was given to it.

The learners have given the least attention to the agriculture cluster in the ROSME findings. The PISA designers gave no attention to agricultural issues and this concurs with young people's interest.

Sport was ranked low by the grade 10 learners and also had a low frequency on the PISA test. This is surprising given the high exposure learners are given to sport internationally.

4.5 Conclusion

The ROSME grade ten learners mostly preferred the intra-mathematical clusters, namely mathematics and mathematicians' practices, whilst the extra-mathematical clusters, technology and health followed respectively as shown in figure 4.1. Agriculture and the youth culture were the lowest ranking clusters.

The PISA instrument provided the following results: The mathematical cluster stood out above the rest and no reference was made about mathematician's practices, whilst the extra-mathematical clusters, physical science and finance followed respectively. The PISA designers did not include health, technology, sport and life sciences; and also did not set questions that were set on youth culture, agriculture, production, crime and politics. The PISA designers put a high emphasis on the pure mathematical context which is in agreement with the learners ranking this cluster as their most preferred.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study investigated the context preferred by the designers of the PISA Mathematical Literacy instrument and how they compare with the contexts grade 10 learners are interested in.

5.2 Answer to the research question

The Department of Education has embarked on a mission to increase the number of learners who take Mathematics as a subject. One of its initiatives is the introduction of Dinaledi Schools, that is, schools that focus on Science and Mathematics education and are consequently given additional resources to facilitate and promote their programmes. These schools are situated in predominantly disadvantaged communities.

The Department of Education also introduced Mathematical Literacy as a compulsory subject for those learners who do not take Mathematics as a subject in order to increase the general mathematical awareness and literacy of the population.

The above-mentioned concerted efforts by the Department of Education (2004a) to emphasize the importance of Mathematics could be regarded as successful in the sense that learners are well informed about the importance of Mathematics.

A prominent feature of the ROSME study is the fact that the intra- mathematics clusters were rated the highest by the grade ten learners. When considering the individually ranked items in this cluster, such as the fact that Mathematics will help learners to do Mathematics at tertiary institutions, and secondly that it is relevant to professional careers, this is indicative of an awareness of Mathematics as a gateway subject. One can conclude from this that learners aspire to acquire a social personal and economic advantage.

In the extra-mathematical cluster the learners favoured technology and health. As presented earlier, the influx of technology in post-apartheid South Africa would logically be expected to have stimulated technology interest among learners.

One could speculate that the huge HIV/AIDS campaign could be responsible for learners desire to know more about the mathematical context in the health industry.

However, it would be reasonable to expect that the interest in the technology and health are not driven by social consciousness *per se* but by an awareness of the financial rewards offered by the careers in the technological and health industries. This would be a logical deduction based on the fact that there is such a high interest in the fact that Mathematics is a requirement for further education at tertiary institutions.

This view is supported by the low ranking of the sport and agriculture clusters as contexts for the learning of mathematics. The perception might be that these fields do not require Mathematics and are probably not regarded as first choice careers.

The fact that finance ranked third behind technology and health would support the notion that there are definite correlations between career aspirations and the importance of Mathematics.

The PISA instrument is an internationally standardized assessment method that the OECD uses to assess 15 year-olds' problem solving abilities. The PISA findings have a high focus on three clusters: Mathematics, Physical Science and Finance. There are no mathematicians contextual items found in the PISA findings. The author concludes that this could most likely be due to the fact that in developed economies there is no need to attract students to the study of Mathematics since it is widely acknowledged to be an essential subject.

The fact that Physical Science and Finance are rated so highly among the mathematical contexts that is assessed might be indicative of the value that is attached to these fields in developed economies.

In comparison with those of ROSME, the PISA findings show a correlation with the high regard for Finance as a mathematical context to be evaluated and as a context that is desired in the South African study.

On the other hand, whilst South African learners favoured the technology context for the study of Mathematics, it is not emphasized by PISA. It seems that the PISA designers favour a strong algorithmic approach.

Sports score low in the PISA findings and no attention was given to agriculture. In the ROSME study, sports and agriculture also have a low preference among the grade ten learners.

Considering the scientific, technological and financial successes of the OECD countries, the question could be asked whether or not there should be a correlation between learners preferences in the various mathematical contexts and the context that are assessed. This could form the subject of a separate study. The assumption that has been made in this study however, is that there should be a correlation between the context that appears in an assessment and the context that learners prefer.

5.3 Limitations of the study

The following were the main limitations and constraints that were encountered during this study:

- Firstly, the different contextual situations such as political and sporting issues as contexts for Mathematics or Mathematical Literacy were pre-determined, although some provisions were made for learners to add some other context of their preferences.

- Secondly, the study was only limited to Grade 10 learners' perceptions of the context they preferred to deal with in Mathematical Literacy.

- Thirdly, parents and teachers had low participation in this study.

5.4 Recommendations

Based on the key findings of this work the following recommendations are made:

- South African mathematics assessments should contain the inter-mathematical technology, health and finance clusters.

- The emphasis that is put in PISA should not be uncritically copied.

5.5 Conclusions

To conclude, the author also concurs with the view that grade 10 learners wish to learn about Mathematics in order to enable them to pursue tertiary studies, which will enable them to enter professional careers. This conclusion was also made by Snyders (2006:54) in his study of the context learners prefer, to those reflected by the TIMMS survey. Hence the emphasis in terms of mathematical contexts that are assessed, should be those career fields that are the most sought after, and would probably imply that mathematical assessments adopt a utilitarian character.

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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
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	

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

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

Educator: ....

School: ....

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

Exampler indicator item of PISA	Cluster
(see below)	

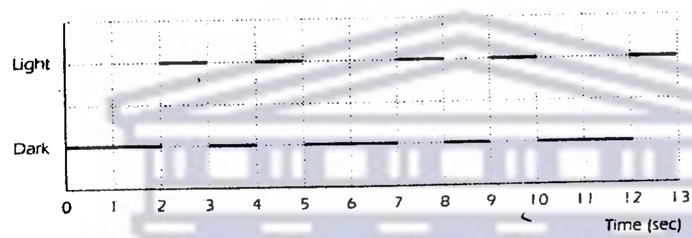
Mathematics Unit 1

LIGHTHOUSE

Lighthouses are towers with a light beacon on top. Lighthouses assist sea ships in finding their way at night when they are sailing close to the shore.

A lighthouse beacon sends out light flashes with a regular fixed pattern. Every lighthouse has its own pattern.

In the diagram below you see the pattern of a certain lighthouse. The light flashes alternate with dark periods.



It is a regular pattern. After some time the pattern repeats itself. The time taken by one complete cycle of a pattern, before it starts to repeat, is called the period. When you find the period of a pattern, it is easy to extend the diagram for the next seconds or minutes or even hours.

Mathematics Example 1.1

Which of the following could be the period of the pattern of this lighthouse?

A. 2 seconds.
B. 3 seconds.
C. 5 seconds.
D. 12 seconds

Mathematics Example 1.2

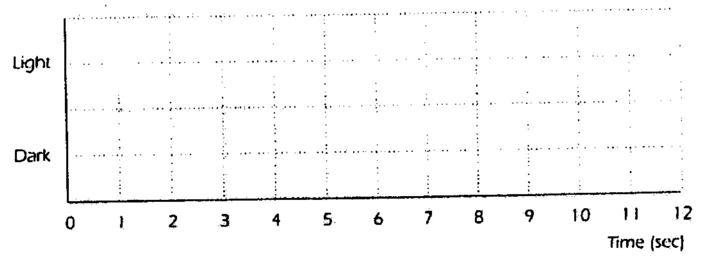
For how many seconds does the lighthouse send out light flashes in 1 minute?

A. 4
B. 12
C. 20
D. 24

Exampler indicator item of PISA	Cluster

Mathematics Example 1.3

In the diagram below, make a graph of a possible pattern of light flashes of a lighthouse that sends out light flashes for 30 seconds per minute. The period of this pattern must be equal to 6 seconds.



Mathematics Unit 2

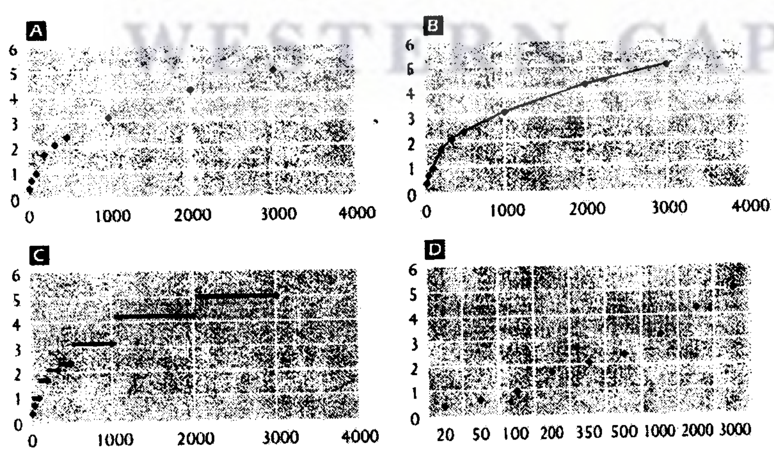
POSTAL CHARGES

The postal charges in Zedland are based on the weight of the items (to the nearest gram), as shown in the table below:

Weight (to nearest gram)	Charge
Up to 20 g	0.46 zeds
21 g – 50 g	0.69 zeds
51 g – 100 g	1.02 zeds
101 g – 200 g	1.75 zeds
201 g – 350 g	2.13 zeds
351 g – 500 g	2.44 zeds
501 g – 1000 g	3.20 zeds
1001 g – 2000 g	4.27 zeds
2001 g – 3000 g	5.03 zeds

Mathematics Example 2.1

Which one of the following graphs is the best representation of the postal charges in Zedland?
(The horizontal axis shows the weight in grams, and the vertical axis shows the charge in zeds.)



Exampler indicator item of PISA	Cluster

Mathematics Unit 4
PAYMENTS BY AREA

> People living in an apartment building decide to buy the building. They will put their money together in such a way that each will pay an amount that is proportional to the size of their apartment.
>
> For example, a man living in an apartment that occupies one fifth of the floor area of all apartments will pay one fifth of the total price of the building.

Mathematics Example 4.1

Circle Correct or Incorrect for each of the following statements.

Statement	*Correct / Incorrect*
A person living in the largest apartment will pay more money for each square metre of his apartment than the person living in the smallest apartment.	Correct / Incorrect
If we know the areas of two apartments and the price of one of them we can calculate the price of the second.	Correct / Incorrect
If we know the price of the building and how much each owner will pay, then the total area of all apartments can be calculated.	Correct / Incorrect
If the total price of the building were reduced by 10%, each of the owners would pay 10% less.	Correct / Incorrect

Mathematics Example 4.2

There are three apartments in the building. The largest, apartment 1, has a total area of $95m^2$. Apartments 2 and 3 have areas of $85m^2$ and $70m^2$ respectively. The selling price for the building is 300 000 zeds.

How much should the owner of apartment 2 pay? Show your work.

Mathematics Unit 5
STUDENT HEIGHTS

Mathematics Example 5.1

In a mathematics class one day, the heights of all students were measured. The average height of boys was 160 cm, and the average height of girls was 150 cm. Alena was the tallest – her height was 180 cm. Zdenek was the shortest – his height was 130 cm.

Two students were absent from class that day, but they were in class the next day. Their heights were measured, and the averages were recalculated. Amazingly, the average height of the girls and the average height of the boys did not change.

Exampler indicator item of PISA	Cluster

Which of the following conclusions can be drawn from this information?

Circle "Yes" or "No" for each conclusion.

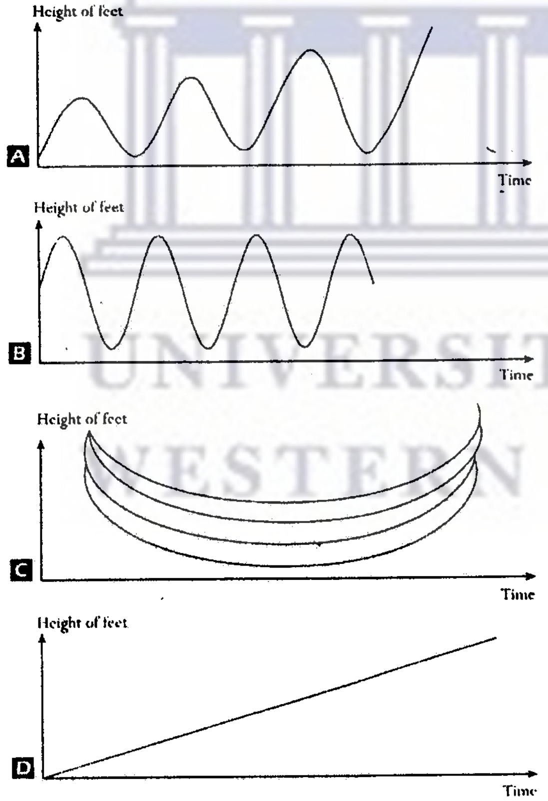
Conclusion	*Can this conclusion be drawn?*
Both students are girls.	Yes / No
One of the students is a boy and the other is a girl.	Yes / No
Both students have the same height.	Yes / No
The average height of all students did not change.	Yes / No
Zdenek is still the shortest.	Yes / No

Mathematics Unit 6
SWING

Mathematics Example 6.1

Mohammed is sitting on a swing. He starts to swing. He is trying to go as high as possible.

Which diagram best represents the height of his feet above the ground as he swings?



Exampler indicator item of PISA	Cluster

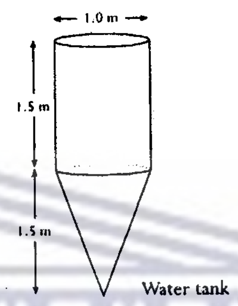
Mathematics Unit 7
WATER TANK

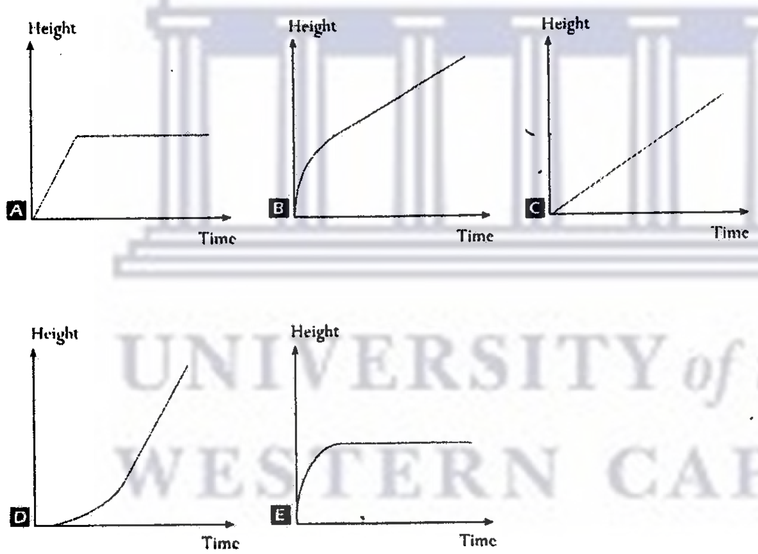
Mathematics Example 7.1

A water tank has shape and dimensions as shown in the diagram.

At the beginning the tank is empty. Then it is filled with water at the rate of one litre per second.

Which of the following graphs shows how the height of the water surface changes over time?





Exampler indicator item of PISA	Cluster

Mathematics Unit 8

REACTION TIME

In a sprinting event, the "reaction time" is the time interval between the starter's gun firing and the athlete leaving the starting block. The "final time" includes both this reaction time, and the running time.

The following table gives the reaction time and the final time of 8 runners in a 100 metre sprint race.

Lane	Reaction time (sec)	Final time (sec)
1	0.147	10.09
2	0.136	9.99
3	0.197	9.87
4	0.180	Did not finish the race
5	0.210	10.17
6	0.216	10.04
7	0.174	10.08
8	0.193	10.13

Mathematics Example 8.1

Identify the Gold, Silver and Bronze medallists from this race. Fill in the table below with the medallists' lane number, reaction time and final time.

Medal	*Lane*	*Reaction time (sec)*	*Final time (sec)*
Gold			
Silver			
Bronze			

Mathematics Example 8.2

To date, no humans have been able to react to a starter's gun in less than 0.110 second.

If the recorded reaction time for a runner is less than 0.110 second, then a false start is considered to have occurred because the runner must have left before hearing the gun.

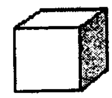
If the Bronze medallist had a faster reaction time, would he have had a chance to win the Silver medal? Give an explanation to support your answer.

Exampler indicator item of PISA	Cluster

Mathematics Unit 9

BUILDING BLOCKS

Susan likes to build blocks from small cubes like the one shown in the following diagram:



Small cube

Susan has lots of small cubes like this one. She uses glue to join cubes together to make other blocks.

First, Susan glues eight of the cubes together to make the block shown in Diagram A:

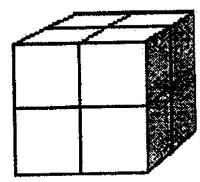


Diagram A

Then Susan makes the solid blocks shown in Diagram B and Diagram C below:

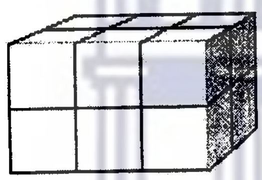


Diagram B

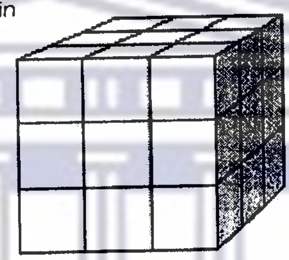


Diagram C

Mathematics Example 9.1

How many small cubes will Susan need to make the block shown in Diagram B?

Answer: .... cubes.

Mathematics Example 9.2

How many small cubes will Susan need to make the solid block shown in Diagram C?

Answer: .... cubes.

Mathematics Example 9.3

Susan realises that she used more small cubes than she really needed to make a block like the one shown in Diagram C. She realises that she could have glued small cubes together to look like Diagram C, but the block could have been hollow on the inside.

What is the minimum number of cubes she needs to make a block that looks like the one shown in Diagram C, but is hollow?

Answer: .... cubes.

Exampler indicator item of PISA	Cluster

Mathematics Unit 10
DRUG CONCENTRATIONS

Mathematics Example 10.1

A woman in hospital receives an injection of penicillin. Her body gradually breaks the penicillin down so that one hour after the injection only 60% of the penicillin will remain active.

This pattern continues: at the end of each hour only 60% of the penicillin that was present at the end of the previous hour remains active.

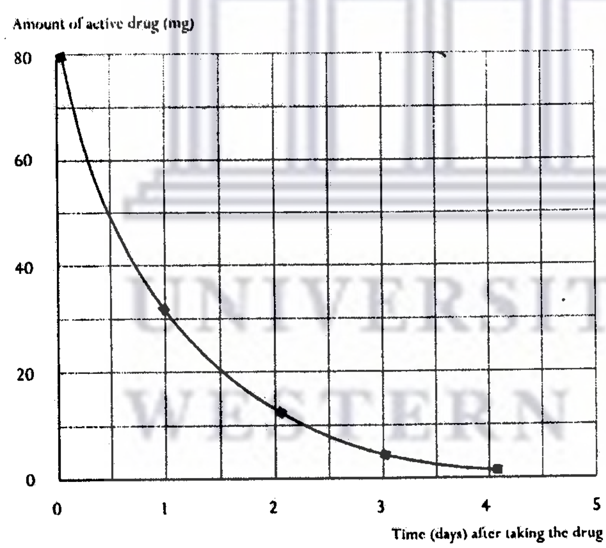
Suppose the woman is given a dose of 300 milligrams of penicillin at 8 o'clock in the morning.

Complete this table showing the amount of penicillin that will remain active in the woman's blood at intervals of one hour from 0800 until 1100 hours.

Time	0800	0900	1000	1100
Penicillin (mg)	300			

Mathematics Example 10.2

Peter has to take 80 mg of a drug to control his blood pressure. The following graph shows the initial amount of the drug, and the amount that remains active in Peter's blood after one, two, three and four days.



How much of the drug remains active at the end of the first day?

A. 6 mg.

B. 12 mg.

C. 26 mg.

D. 32 mg.

Exampler indicator item of PISA	Cluster

Mathematics Example 10.3

From the graph for the previous question it can be seen that each day, about the same proportion of the previous day's drug remains active in Peter's blood.

At the end of each day which of the following is the approximate percentage of the previous day's drug that remains active?

A. 20%.

B. 30%.

C. 40%.

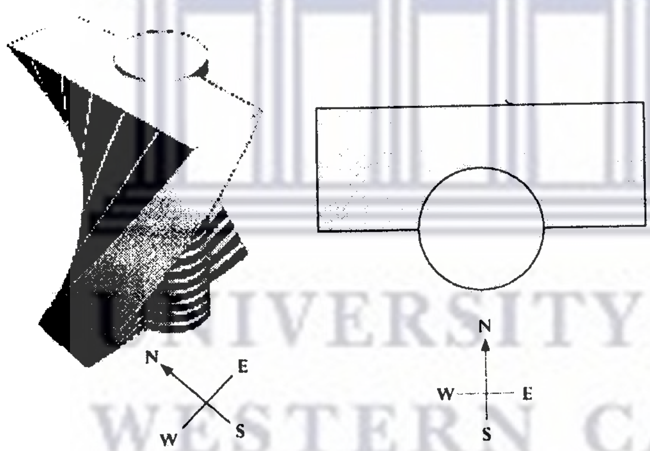
D. 80%.

Mathematics Unit 11

TWISTED BUILDING

In modern architecture, buildings often have unusual shapes. The picture below shows a computer model of a "twisted building" and a plan of the ground floor.

The compass points show the orientation of the building.



The ground floor of the building contains the main entrance and has room for shops. Above the ground floor there are 20 storeys containing apartments.

The plan of each storey is similar to the plan of the ground floor, but each has a slightly different orientation from the storey below. The cylinder contains the elevator shaft and a landing on each floor.

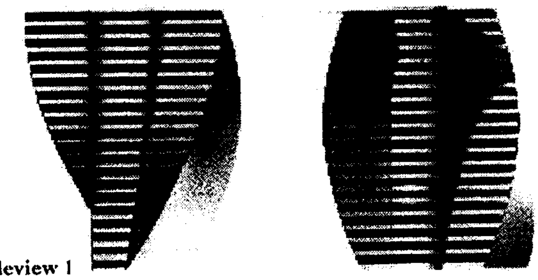
Mathematics Example 11.1

Estimate the total height of the building, in metres. Explain how you found your answer.

Exampler indicator item of PISA	Cluster

Mathematics Example 11.2

The following pictures are sideviews of the twisted building.



Sideview 1 Sideview 2

From which direction has Sideview 1 been drawn?

A. From the North.

B. From the West.

C. From the East.

D. From the South.

Mathematics Example 11.3

From which direction has Sideview 2 been drawn?

A. From the North West.

B. From the North East.

C. From the South West.

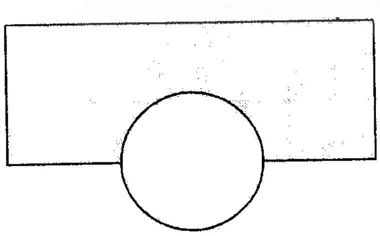
D. From the South East.

Mathematics Example 11.4

Each storey containing apartments has a certain "twist" compared to the ground floor. The top floor (the 20th floor above the ground floor) is at right angles to the ground floor.

The drawing below represents the ground floor.

Draw in this diagram the plan of the 10th floor above the ground floor, showing how this floor is situated compared to the ground floor.



Exampler indicator item of PISA	Cluster

Mathematics unit 12

ROCK CONCERT

Mathematics Example 12.1

For a rock concert a rectangular field of size 100 m by 50 m was reserved for the audience. The concert was completely sold out and the field was full with all the fans standing.

Which one of the following is likely to be the best estimate of the total number of people attending the concert?

A. 2 000

B. 5 000

C. 20 000

D. 50 000

E. 100 000

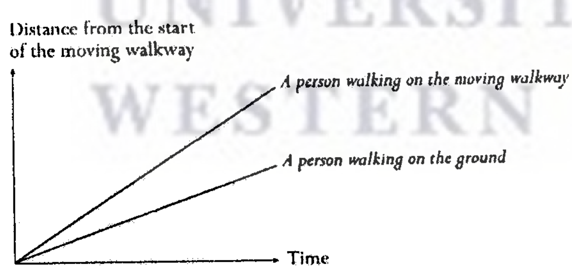
Mathematics Unit 13

MOVING WALKWAYS

Mathematics Example 13.1

On the right is a photograph of moving walkways.

The following Distance-Time graph shows a comparison between "walking on the moving walkway" and "walking on the ground next to the moving walkway."



Assuming that, in the above graph, the walking pace is about the same for both persons, add a line to the graph that would represent the distance versus time for a person who is standing still on the moving walkway.

Appendix 5: Educators Clustering of PISA items

Educator: ....

School: ....

ROSME Clusters				
Mathematics	Mathematician's Practices	Transport & Delivery	Health	Agriculture
Physical Science	Technology	Life Science	Sport	Politics
Youth Culture	Finance	General		

Choose from one of the above ROSME Clusters, which describe the Exampler indicator item of PISA the best.

Exampler indicator item of PISA	ROSME Cluster
Mathematical Unit 1	
Mathematical Unit 2	
Mathematical Unit 3	
Mathematical Unit 4	
Mathematical Unit 5	
Mathematical Unit 6	
Mathematical Unit 7	
Mathematical Unit 8	
Mathematical Unit 9	
Mathematical Unit 10	
Mathematical Unit 11	
Mathematical Unit 12	
Mathematical Unit 13	

Appendix 6: Clustering of PISA items

Mathematics	Mathematician's Practices	Transport & Delivery	Health	Agriculture
Physical Science	Technology	Life Science	Sport	Politics
Youth Culture	Finance	General		

Exampler indicator item of PISA	% Agreement	Number of Items	Cluster
Mathematical Unit 1	67 %	4	Mathematics
Mathematical Unit 2	83%	4	Mathematics
Mathematical Unit 3	100%	1	Health
Mathematical Unit 4	67 %	2	Finance
Mathematical Unit 5	50%	4	Mathematics
Mathematical Unit 6	67 %	2	Physical Science
Mathematical Unit 7	83%	2	Physical Science
Mathematical Unit 8	100%	1	Sport
Mathematical Unit 9	100%	4	Mathematics
Mathematical Unit 10	67 %	1	Life Science
Mathematical Unit 11	83%	1	Technology
Mathematical Unit 12	50%	2	Finance
Mathematical Unit 13	50%	1	General