The rationale for teaching Quantitative Literacy in 21st century South Africa: A case for the renaming of Mathematical Literacy

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In 2014 Umalusi (Council for Quality Assurance in General and Further Education and Training) proposed research into Mathematical Literacy to determine whether the content and skills in Mathematical Literacy compare with the problem-solving skills considered necessary to be quantitatively literate by world standards. The team of researchers transformed this question into three questions.

1. What is Quantitative Literacy? What are its main characteristics (i.t.o. knowledge, skills and attitudes)?
2. Does Mathematical Literacy cover the skills considered to be necessary to be quantitatively literate by world standards?
3. To what extent does the Curriculum and Assessment Policy Statement (CAPS) for Mathematical Literacy encompass the skills and knowledge required for arithmetical / mathematical / quantitative problem solving with respect to content, depth and breadth?

The paper answers these three questions in depth using an extensive literature survey of writing about Quantitative Literacy as it is described internationally. The mathematical content and skills of Mathematical Literacy are compared to the internationally equivalent subjects, both in breadth and depth. A reflection follows on the effectiveness of these skills to equip students to solve real-life quantitative problems in the 21st century as well as to be a reliable admission requirement for non-Science university studies. Finally the paper provides a strong motivation for a name change for this subject in South Africa.

Keywords: Mathematical Literacy, Quantitative Literacy, Numeracy, Quantitative skills, contextual mathematics, Umalusi curriculum research

INTRODUCTION

What's in a name? That which we call a rose by any other name would smell as sweet.
(Shakespeare, 1600. Romeo and Juliet).

Mathematical Literacy is a school subject taught in Grades 10 – 12 at secondary school level in all South African schools. It is a compulsory subject choice for all learners who do not do Mathematics at Grade 12. In South Africa, (and England since 2010), the subject is taught at secondary school level; in the United States it is taught at university and colleges, in some instances to provide access to advanced Mathematics courses. There is a common perception among most South Africans that Mathematical Literacy is 'maths for dumb kids' or 'just like standard grade maths' or 'that it's a basic function (like reading and writing which was done in Grade 1)'. Concerned parents do not want their children to 'drop down' to Mathematical Literacy. Some say 'it's Maths for those who can't do Maths' (Hamsa and Graven, 2006: 26). There is also a commonly held view among those in Higher Education that Mathematical Literacy is not a useful matric subject to offer for admission to higher education. Those who take Mathematics are considered to possess high mental prowess, be capable of abstract thinking and be able to solve complex problems. In contrast those who take Mathematical Literacy are thought to be capable of merely low-level, arithmetical thinking and computational skills.

One of the purposes of this paper is to refute these assertions and to provide factual evidence for why these perceptions and views are ill-founded. In the opinion of the Umalusi research team the perceptions described above are largely based on ignorance of the actual nature of Mathematical Literacy, the inadequate naming of the subject and a lack of understanding of how Mathematical Literacy has filled the vacuum left by educational changes and perspectives in South Africa since the 19th century in a radical way.

RESEARCH METHODOLOGY

In 2014, Umalusi (Council for Quality Assurance in General and Further Education and Training) proposed a research question into Mathematical Literacy to determine whether the content and skills in Mathematical Literacy compare with the problem-solving skills deemed necessary to be quantitatively literate by world standards. The team of researchers transformed this question into three questions.

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The research methodology included both quantitative and qualitative methods. The Umalusi research team, representing the teaching practice, curriculum and field experts as well as representation from higher education institutions, researched the history of education in South Africa since the 19th century, education acts and the types of quantitative knowledge and skills which are required for people to function optimally in the home, the workplace and in society in the 21st century. The literature survey included books, conference proceedings, papers, websites, current research and theses. The time given by Umalusi did not permit the authors to extend their research to survey the opinions of Mathematical Literacy teachers and learners, who, of course, constitute a very important sector with respect to the questions above. This would be a very significant and rich study for further research and might add fuel to the argument for higher education leaders to review their policies regarding Mathematical Literacy as a subject for admission.

BACKGROUND TO THE REASON FOR THE INTRODUCTION OF MATHEMATICAL LITERACY IN SOUTH AFRICA

Education in South Africa in the 19th and 20th centuries

In the period from 1800 to 1953 education for black children consisted basically of missionary education (Van der Walt, 1992). Much has been written about both the positive aspects of the missionary endeavour as well as some negative impacts. Suffice to say, many key leaders in South Africa attribute their educational beginnings to the efforts of mission-based teachers. Notwithstanding the colonial context of this education the outcomes were, in many cases, pivotal for the children concerned and for the history of the country.

The Bantu Education Act of 1953

When the National Party won the elections in 1948, racial segregation of black education was formalised and culminated in the passing of the Bantu Education Act of 1953. This Act, based largely on the recommendations of the Eiselen Commission (Ramoketsi, 2008), was to become the National Party's blueprint for education of black children. Armed with the Bantu Education Act of 1953, the government stated categorically that the education provided by missionaries could not be relied upon to root black people within their own 'tribal community' and that it had to be State-controlled in order to do so, as recommended by the Eiselen Commission.

Obviously, there was opposition to the implementation of Bantu Education which resulted in the demise of the work done by mission schools in providing education to black children, and this opposition came very strongly from black people themselves, and in particular from political organisations (e.g. the ANC and the White Liberal Party), from national community organisations (e.g. the Black Sash organised by women) and from other White South Africans. The national authorities of the time are often said to have viewed education as having a pivotal position in their goal of eventually separating (white) South Africa from the Bantustans. With specific reference to black learners, education in general and Mathematics learning and teaching, Dr Hendrik Verwoerd, in a speech delivered on 17 September 1953 on the Second Reading of the Bantu Education Bill, stated:

> When I have control over native education I will reform it so that the Natives will be taught from childhood to realize that equality with Europeans is not for them. People who believe in equality are not desirable teachers for Natives…There is no place for [the Bantu] in the European community above the level of certain forms of labour ... What is the use of teaching the Bantu child mathematics when it cannot use it in practice? (Clark & Worger, 2004).

Verwoerd's policies of discrimination meant that blacks learners were discouraged from taking Mathematics as one of the subjects at school as noted above when he said 'What is the use of teaching the Bantu child mathematics when it cannot use it in practice?' Hence, many black learners could not take Mathematics as a subject through to the end of their secondary/high school studies since many schools did not anyway offer Mathematics at the senior secondary level. For instance, according to a report commissioned by the Department of Education and Training and the Department of Arts, Science and Technology, by 1997 KwaZulu-Natal still had 156 high schools that did not offer Mathematics at the Grade 12 level (Arnott, Kubeka, Rice & Hall, 1997).

Most teacher training during the apartheid years took place at segregated and apartheid-constructed teacher training institutions, the so-called 'Colleges of Education', and many black teachers in South Africa received training at these colleges where they could either take a two-year certificate course, or a three-year diploma course. The Primary Teachers Certificate (PTC) was a two-year certificate course that enabled teachers to teach at a primary school and the Junior Secondary Teachers Certificate (JSTC) enabled teachers to teach up to Junior Secondary schools.

From the 1980s, the Colleges of Education, which had proliferated in numbers in the homelands and self-governing states (Chisholm, 2009), started offering an improved curriculum, compared to the two-year certificate courses, and it consisted of a three-year Primary Teachers Diploma and/or Secondary Teachers Diploma. Nevertheless, the curricula in these diploma courses still did not reach the required standards and provide quality education as expected by many scholars and educators (Arnott et al., 1997). For instance, teachers who were trained to teach Mathematics at senior secondary level did not do any Mathematics beyond Grade 12. In other words, the mathematical knowledge that the Mathematics teachers would obtain after spending three years at a College of Education would be the same as the learners they would be teaching at high schools. They did not have the benefit of having more mathematical knowledge than their learners which would have enabled them to have greater confidence, insight and understanding of the subject they would be teaching at Grades 10-12. Furthermore they had minimal opportunities to strengthen their subject knowledge base for teaching. Arnott et al. (1997) actually reported, in their 1997 audit of Mathematics and Science teacher education that over 50% of the secondary level Mathematics teachers at that time had less than one year of post-secondary study in the subject. Due to the challenges that black Mathematics teachers encountered, including the inadequate training, the quality and standard of teaching and learning of Mathematics in black schools was called into question. What this has translated into is the fact that Bantu Education has led to the current poor performance in Mathematics of South African learners today. Kahn (2001) observes that the pass rate for Grade 12 black learners in Mathematics in 1999, 2000, 2001 and 2002 was 17.7%, 15.6%, 20% and 23.2% respectively. This situation has had a cascading effect since poorly qualified teachers produced low achieving mathematics matriculants, who also then, if they choose to take teaching as a profession, become poorly qualified mathematics teachers.

The South African Schools Act, no. 84 of 1996

The South African Schools Act, no. 84 of 1996, sought to ensure a uniform system in schools. One of the main objectives of the Act was to amend and repeal certain laws relating to schools and to provide for related matters. The Act recognised that a new national system for schools needed to redress past injustices, and to support the rights of learners, educators and parents. It also set out the duties and responsibilities of the State. Under apartheid South Africa, there were 19 education departments, and eight of these used different curricula and offered different standards of learning quality. These included nation-wide departments for coloured learners, Indian learners, black learners, a department for independent schools, and provincial departments for white learners in each of the former four provinces. Some of the homelands and self-governing territories that were incorporated back into South Africa in 1994 also had their own education departments, but the curricula used and followed were from the nation-wide department for black learners.

According to Msila (2007) it is partly the history of South African education that necessitated the introduction of Curriculum 2005 from January 1998. It was clear that the previous education system had fallen short of international standards. In addition, the transition and transformation from apartheid education to a new South African education system needed to be rooted within the fundamental values enshrined in the democratic Constitution; values such as, democracy, social justice, non-racism, non-sexism, equality and reconciliation were seen as very important in the newly founded South African democracy. Consequently, the Outcomes Based-Education (OBE) system basically introduced new learning styles where, for example, there was change from passive, rote learning to creative learning and problem solving through learners' active participation in the learning process. However, the introduction and implementation of OBE was made more difficult by the fact that many teachers were not part of the formulation of the curriculum process (Jansen, 1997).

Subsequently, Curriculum 2005 and its implementation were reviewed by a Ministerial Committee in 2000, and the Revised National Curriculum Statement was formulated which was 'not to be seen as a new

curriculum but a streamlining and strengthening of Curriculum 2005' (Department of Education, 2002: 6). According to the Department of Education, the Revised National Curriculum Statement would keep intact the principles, purposes and thrust of Curriculum 2005 and still affirmed the commitment to outcomes-based education. When the Revised National Curriculum Statement Grades R-9 (Schools) became policy, it would replace Curriculum 2005, and its introduction in the Foundation Phase was planned for 2004.

The introduction of Mathematical Literacy

To complete the cycle of the introduction of a new curriculum, the National Curriculum Statement for Grades 10-12 was to be implemented and introduced in Grade 10 in 2006, Grade 11 in 2007 and Grade 12 in 2008. The National Curriculum Statement at the time required all learners in Grades 10-12 to do seven subjects. In fact, to be awarded the National Senior Certificate, learners had to complete seven (7) subjects and also meet stated minimum requirements. The subjects were specified as follows: two (2) South African languages, Mathematics or Mathematical Literacy, Life Orientation, and three (3) choice subjects. In other words, the National Curriculum Statement (Grade 10-12) came with a requirement that all learners had to do either Mathematics or Mathematical Literacy.

The big question was:

> Why introduce a new subject, namely, Mathematical Literacy, and what was the purpose?

According to the Department of Education, Mathematical Literacy is defined as a subject that

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

The Department of Education (2003) argued that South Africa has come from a past in which poor quality education or lack of education has resulted in very low levels of literacy and numeracy in our adult population. International studies have shown that South African learners fare very poorly in mathematical competence tests when compared to their counterparts in other developed and developing countries. In the Trends in International Mathematics and Science Study (TIMSS) which is a series of international assessments of the mathematics and science knowledge of students around the world, South Africa scored the lowest for mathematics in 1995 (out of 41 countries), in 1999 (out of 48 countries) and in 2003 (out of 45 countries). (The TIMMS results for 2011 show a significant improvement from the previous very low scores of South African learners. However, their ranked position has not altered in comparison to the other countries tested.) Prior to the introduction of Mathematical Literacy, learners who did not achieve a pass mark in Mathematics in the General Education and Training Phase usually dropped Mathematics at the end of Grade 9, thus contributing to a perpetuation of high levels of innumeracy.

The inclusion of Mathematical Literacy as a fundamental subject in the Further Education and Training curriculum is to ensure that our citizens of the future are highly numerate users of mathematics. In the teaching and learning of Mathematical Literacy, the intention is to provide learners with opportunities to engage with real-life problems in different contexts, and so to consolidate and extend basic mathematical skills. Thus, Mathematical Literacy, properly taught, will result in the ability to understand mathematical terminology and to make sense of numerical and spatial information communicated in tables, graphs, diagrams and texts. Furthermore, Mathematical Literacy intentionally develops the use of basic mathematical skills in critically analysing situations and creatively solving everyday problems.

Before the National Curriculum Statement was introduced, learners could choose to take Mathematics on Higher Grade level, Standard Grade level or not at all. The 'not at all' part is the dismaying statistic.

Brombacher (2010), who was an adviser and consultant for the Minister of Education with regard to the compulsory requirement for learners in Grades 10-12 to take either Mathematics or Mathematical Literacy, revealed some interesting statistics. These statistics could have swayed the Ministry's decisions on the matter: he noted that as many as 40% of learners were not taking any Mathematics at all each year during the period 2000-2005. Furthermore, about half the learners who took Mathematics were taking it on the Standard Grade level. Over the same period 2000-2005, the average percentage of learners out of the entire cohort of the Matriculation examination candidates who got a mere pass in Higher Grade Mathematics was a mere 5.2%.

Mathematical Literacy was introduced in schools in the FET Phase (Grades 10-12, with learners mainly aged between 15 and 18) in South Africa during January 2006. According to Botha (2011), in 2006 South Africa was the only country in the world to offer Mathematical Literacy as a subject at school. According to Christiansen (2006), 200 000 more learners were given the opportunity in 2006 to interact with mathematics than in previous years when mathematics was not obligatory for all learners. Consequently, Christiansen (2006) asserts that Mathematical Literacy will offer greater access to mathematics for all learners and could offer a more accessible opportunity for learners to succeed in a mathematical subject. The implementation of this mandatory subject has resulted in renewed national interest in mathematics transformation in South Africa, challenging the mathematics educational experts to look more deeply into the purposes, principles and scope of this transformation in order to ensure its successful implementation. Policy makers and interested parties in certain quarters even went as far as suggesting that Mathematical Literacy should be offered as one of the mandatory subjects instead of a choice subject as it prepared learners for real-life situations.

THE MAIN CHARACTERISTICS OF 'QUANTITATIVE LITERACY'

The survey of literature resulted in a compilation of 32 definitions of a subject which is variously called Mathematical Literacy (mainly in South Africa), Quantitative Literacy (mainly in the USA and Hong Kong), Quantitative Reasoning (mainly in the USA), Numeracy (worldwide) or Functional Mathematics (England). (For the purposes of this paper and for ease of comparison with Mathematical Literacy the four last-named subjects, as a group, will be called 'Quantitative Literacy' in the rest of this paper. However, when the context requires that all four be named they will be listed separately.) The analysis of definitions involved looking for common or very similar words and common or very similar ideas. It also involved considering the meaning of the definition as a whole. A list of the quantitative skills in Quantitative Literacy, Quantitative Reasoning, Numeracy and Functional Mathematics was identified and grouped into five subsets:

- computational skills
- application of mathematical content
- reasoning skills
- statistical analysis and application skills
- communication skills.

These skills were then compared in great detail to the skills described in the *Curriculum and Assessment Policy Statement for Mathematical Literacy.* See Annexure 1.

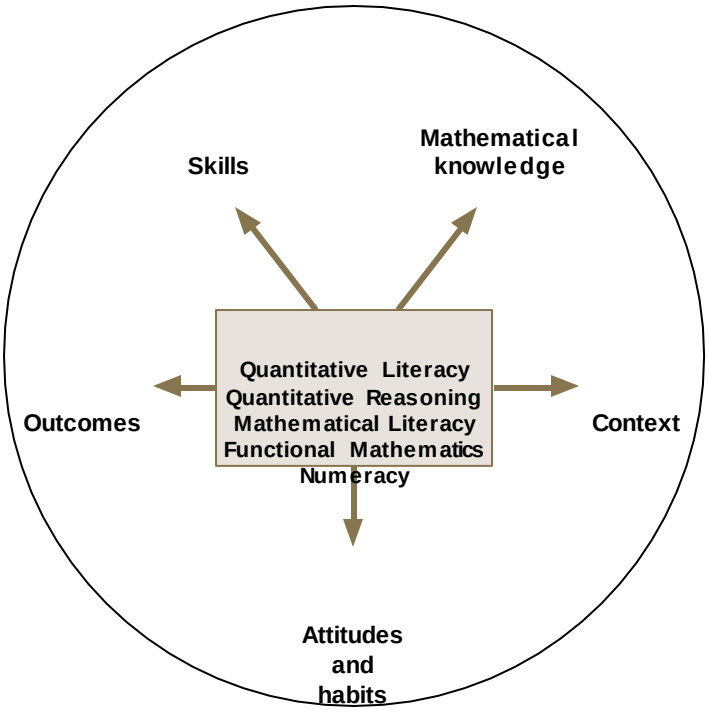
Another outcome of the survey was a comparison of the mathematical knowledge/content in Quantitative Literacy, Quantitative Reasoning, Numeracy and Functional Mathematics and the mathematical knowledge/content in the *Curriculum and Assessment Policy Statement (CAPS) for Mathematical Literacy* in South Africa. The full list of this content can be found in Annexure 2.

The layered analysis of the definitions was necessary to determine the relative depth and breadth of the South African curriculum to other curricula, where available and appropriate, and the broad sweep of skills considered necessary for high levels of quantitative functioning. The research team intended to ascertain whether the CAPS for Mathematical Literacy covers the same breadth and depth of mathematical content and the same general set of skills as the international cluster of subjects which purport to enable learners to become quantitatively literate and to be problem solvers of real-life quantitative problems. As mentioned above, the various definitions of Mathematical Literacy and the four international subjects were analysed with respect to skills, mathematical knowledge, attitudes and values, desired outcomes and contexts. The analysis and overall comparison revealed a very large commonality in these areas, namely,

- All are based on the same broad range of mathematical concepts (numeric, graphical, spatial, finance, statistics and probability).
- All require a set of computational skills, a set of mathematical content skills, a set of reasoning skills, a set of statistical analysis skills and a set of communication skills.
- The outcomes are all largely clustered around the improvement of the civic-mindedness and ability of people to cope with the demands of modern society.
- All are context-based and use authentic everyday situations in which to locate problem solving.

In analysing the *definitions* both the *words* chosen to define the subject and the *meaning* conveyed by the overall definition was considered. In the *definitions* found in the literature of these five subjects both knowledge and skills were grouped into subsets that are linked or related or similar in meaning for the purposes of comparison. For instance 'logical deduction' is considered to be an equivalent or very similar skill to 'reasoning'. The following list of the components of the definitions (as shown in Figure 1 below) is based on this grouping of related elements.

Figure 1:
Common features, characteristics and outcomes of Mathematical Literacy, Quantitative Literacy, Quantitative Reasoning, Numeracy and Functional Mathematics



Mathematical Knowledge

- Broad range of basic mathematical concepts (number, ratio, percentage, linear growth, area, volume, etc.)
- Application or engagement with mathematical knowledge, principles and concepts in order to solve problems
- Logic, deduction and reasoning
- Use of real data and uncertain procedures in real-life situations

Skills

- Apply arithmetic operations; process, respond and think about mathematical information (numeric, quantitative, spatial, statistical); use mathematical tools as well as ICT in sophisticated settings
- Estimate values; identify errors; validate assertions
- Solve problems
- Probe given information; analyse and interpret
- Make well-founded judgements and draw conclusions
- Predict; conjecture; model situations mentally and formally
- Communicate - visually, verbally, orally
- Understand and make sense of or engage with context; use appropriate skills in different contexts
- Control or manage situations

Outcomes

- Become concerned, reflective, participating, self-managing, contributing citizens
- Cope with quantitative demands of modern society
- Fundamental component of all learning-performance, discourse and critique

Attitudes and values

- Habits of mind
- Beliefs and dispositions
- Confidence in quantitative situations

Context

- Life-related applications in a variety of contexts, personal, familiar, societal, work-based, unfamiliar

Based on the *definitions* alone, it is quite clearly seen that the content, skills-set and purpose of Mathematical Literacy are almost identical to 'Quantitative Literacy'. There are different emphases in some of the subjects, some of which are linked to the historical origin of the subject. For example Functional Mathematics, which was introduced in all secondary schools for all learners up to GCSE in England in 2010, emphasises the inter-disciplinary nature of being quantitatively functional and it is taught alongside Mathematics (Hamsa and Graven, 2005). Quantitative Literacy, in the USA, is seen in some institutions as a gateway to advanced mathematics courses. (Dossey, 1997). Numeracy includes the need for ICT skills as well as other quantitative skills.

Apart from this in-depth analysis, examination of a selection of actual definitions shows the common characteristics and purpose that the five subjects share:

> People who are ***quantitatively literate*** are able to think and reason across the various aspects of mathematical behaviours, actively use concepts, principles, and skills to make sense out of situations they encounter. This requires that they integrate not only content but also the cognitive processes required to probe, interpret, conjecture, validate and communicate what the various aspects of mathematics reveal about a given situation. The ability to use mathematics as a tool to make sense of situations in the environment requires that people model the situations (mentally or formally), bring to bear their mathematical knowledge and work towards a solution (Dossey, 1997).

Numeracy is '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 to participate effectively in activities they value' (Evans, 2000: 236 cited in Coben et al.).

> If literacy is the ability to read and write, then ***Mathematical Literacy*** should be the ability to read, write, and engage with information and situations that are numerical in nature and mathematical in structure. While the mathematically literate person may draw on mathematical algorithms or knowledge, their mathematical literacy is reflected in habits and behaviours and ways of engaging with problems and situations (AMESA, 2003: 2).

In defining ***Quantitative Reasoning*** a continuum is a useful metaphor, cruder than many and certainly not the only approach to defining quantitative reasoning. But it does provide a useful sense of direction while we think about the effect of computers on the past and future of quantitative reasoning. The Low end: calculating in a fixed and familiar context. The Middle: solving problems in a particular applied context. The High end: reasoning about relationships (Cobb, 1997).

Functional Mathematics in England is currently defined thus:

- Each individual has sufficient understanding of a range of mathematical concepts and is able to know how and when to use them. For example, they will have the confidence and capability to use maths to solve problems embedded in increasingly complex settings and to use a range of tools, including ICT as appropriate.

- In life and work, each individual will develop the analytical and reasoning skills to draw conclusions, justify how they are reached and identify errors or inconsistencies. They will also be able to validate and interpret results, to judge the limits of their validity and use them effectively.

Finally, 'whatever the terms used (*for this subject*) "an emerging concern is with linking knowledge, skills, attitudes and values produced through mathematical literacy to those needed for effective participation in democratic life in the 21st century"' (Vithal, 2006: 37).

From this analysis of definitions the research team asserts that the subject called Mathematical Literacy (in South Africa) is virtually the same subject as taught in other countries under another name. The differences are small and mainly in emphasis.

DOES THE CAPS FOR MATHEMATICAL LITERACY TEACH SKILLS WHICH ENABLE SOUTH AFRICAN MATRICULANTS TO BE QUANTITATIVELY LITERATE BY INTERNATIONAL STANDARDS?

The Umalusi research team undertook a further examination of the similarities between Mathematical Literacy and 'Quantitative Literacy'. The first analysis looked beyond formal definitions to the descriptions

and specification of Quantitative Literacy, Quantitative Reasoning, Numeracy and Functional Mathematics. The next task was to identify the skills found in all these subjects. What follows is the full list of skills that are found in the literature of these subjects.

Table 1:
Skills in 'Quantitative Literacy'

1. Computational Skills

- Apply arithmetic operations, using numbers embedded in print material
- Calculator skills
- Check the reasonableness of calculated values
- Computational / Algorithmic skills
- Use new technologies / Use mathematical tools as well as ICT in sophisticated settings / Computer skills
- Estimate the right order of magnitude of the solution/ Estimation of numbers

2. Application of Mathematical Content

- Actively use concepts and principles
- Apply the mathematical content areas
- Apply elementary mathematical tools in sophisticated settings
- Apply technical knowledge
- Confidence to apply mathematical knowledge
- Life-related application of mathematics
- Problem-solving skills
- Understand multi-variate models
- Understand the impact of different rates of growth
- Use appropriate skills in different contexts / Grounded appreciation of the context

3. Reasoning

- Analyse evidence
- Analyse, synthesise and evaluate
- Confidence to think numerically and spatially
- Use critical thinking skills
- Draw conclusions
- Evaluate the decision that values lead to / Evaluate risks
- Formulate the problem / Develop and interpret models related to problems / Determine the best analytical approach
- Guess and check / Make conjectures
- Identify errors / Detect fallacies
- Integrate content and cognitive processes
- Interpret and critically analyse in order to solve problems
- Interpret the meaning of calculated values
- Judge independently
- Justify an assertion

- Make decisions / good judgements
- Make sense/engage with context
- Make or critique an argument
- Model situations mentally and formally
- Probe information
- Process, respond and think about numeric, quantitative, spatial, statistical, mathematical information
- Reason and think / Reason in numerical, data, spatial and chance settings
- See connections
- Think deductively or logically / Think mathematically and strategise
- Understand
- Validate

4. Statistical Analysis

- Ask the right questions about data
- Assess the quality of the information; assess claims
- Draw inference from data
- Engage meaningfully with personal, social and political issues
- Find information
- Interpret data
- Predict (using probability)
- Recognise the difference between correlation and causation
- Recognise the difference between randomised experiments and observational studies
- Reason statistically
- Understand, predict and control situations important to their lives
- Weigh evidence / Compare

5. Communication

- Use spreadsheets and create other graphic displays on computers
- Communicate findings visually, verbally, orally
- Communicate simple quantitative ideas in English
- Communicate what Mathematics reveals
- Construct, communicate and evaluate an argument
- Interpret, apply and communicate mathematical information
- Language, reading and comprehension / Read, write and engage with numerical information
- Represent answers in text or graphically
- Use written and graph source material
- Use verbal / Interpretive skills

From the list above it can been seen that this set of skills is broad and deep, cognitively demanding and complex, applicable to important problem-solving situations in which we live, very useful and highly relevant to life today. Steen (1997) compares the vulnerability of a quantitatively illiterate citizen in today's society to that of an illiterate peasant in Gutenberg's time, when the printing press was invented. He adds (2007) that democracy itself is in danger if most citizens are '*quantitatively oblivious*'.

The research revealed that the CAPS for Mathematical Literacy shares (with a few minor differences) the five main sets of skills described in the other four subjects.The skills are grouped into five main categories:

- Use basic **computational skills** in everyday contexts
- Apply known **mathematical content**
- **Reason** in order to draw and communicate conclusions
- **Statistically analyse** and represent information
- Use appropriate **communication skills** to participate effectively in the household, workplace or in wider social and political contexts.

The ability to use basic computational skills is evident throughout the CAPS and great attention is given to estimation skills and mathematical tools. The CAPS goes into depth and places emphasis on skills such as reasoning; analysis, interpretation, justification and making sense of real-life contexts as well as application of mathematical content problem-solving skills and life-related application of mathematics. An overarching element of the CAPS is the skill of communicating the answer either verbally or graphically or in some visual representation. The numerous detailed skills in CAPS were grouped to align with the five subsets listed in Table 1 above. The CAPS document is extremely well specified with respect to the skills required to achieve the objectives of Mathematical Literacy. From this survey and comparison it is clear that the skills of Mathematical Literacy correspond very closely with the skills recognised internationally as skills which quantitatively literate people have and use. The detailed comparison of the skills in CAPS and the literature review can be found in Annexure 1: Comparison of skills in the literature review of 'Quantitative Literacy' and skills in the Mathematical Literacy CAPS.

TO WHAT EXTENT DOES THE CURRICULUM AND ASSESSMENT POLICY STATEMENT (CAPS) FOR MATHEMATICAL LITERACY DESCRIBE IN BOTH DEPTH AND BREADTH THE SKILLS AND KNOWLEDGE REQUIRED FOR ARITHMETICAL / MATHEMATICAL / QUANTITATIVE PROBLEM SOLVING?

In order to find answers to this question, the research team compared the mathematical content areas described in the literature in Quantitative Literacy, Quantitative Reasoning, Numeracy and Functional Mathematics with the mathematical content areas described in the CAPS for Mathematical Literacy. The researchers also reflected on the depth and breadth of the specialisation of the skills required in Mathematical Literacy which deal with problem solving. (See Annexure 1.)

In the literature the main areas of problem solving in which people require quantitative skills are Numeric computation, Financial, Spatial (or visual), Statistical and Probability problems. Table 2 below shows how these general areas correspond with the structure and content of Mathematical Literacy.

Table 2:

A comparison of the problem-solving content areas in Mathematical Literacy and 'Quantitative Literacy'

CAPS	Literature review of 'Quantitative Literacy'
Interpreting and communicating answers and calculations	Arithmetic/numeric calculations, Proportional reasoning, e.g. in ratio problems Linear and exponential graphs, Pattern recognition, variables and relations, solving non-linear equations, Working with models of linear and exponential growth
Numbers and calculations with numbers	
Patterns, relationships and representations	

CAPS	Literature review of 'Quantitative Literacy'
Finance	Production rates and price schemes
Measurement	Area of rectangle and circle and volume of rectangular solids, spheres, cylinders and cones, measurement
Maps, plans and other representations	Space and visualisation
Data handling	Extrapolation and fitting lines or curves to data, recording data, statistical analysis (measures of central tendency and dispersion)
Probability	Probability, combinatorics, e.g. combinations and permutations, expressed in tree diagrams and useful in probability

When the detailed content is examined the CAPS for Mathematical Literacy demands slightly more of learners in the mathematical content of the Financial and Spatial topic areas. However, the mathematical content complexity in Mathematical Literacy in Probability and Data handling is not as deep as in some Quantitative Literacy courses in the USA (Ganter, 2006). It should be noted that, whereas the research team had access to the detailed and highly specified CAPS document for Mathematical Literacy, for most of the descriptions of the content areas of the other subjects we had to rely on condensed or bulleted summaries of the content. However, from the overall discussion of the other subjects it can be assumed that much of what is specified in the CAPS is implied in the other curricula.

Other shared problem-solving characteristics of Mathematical Literacy and 'Quantitative Literacy' are:

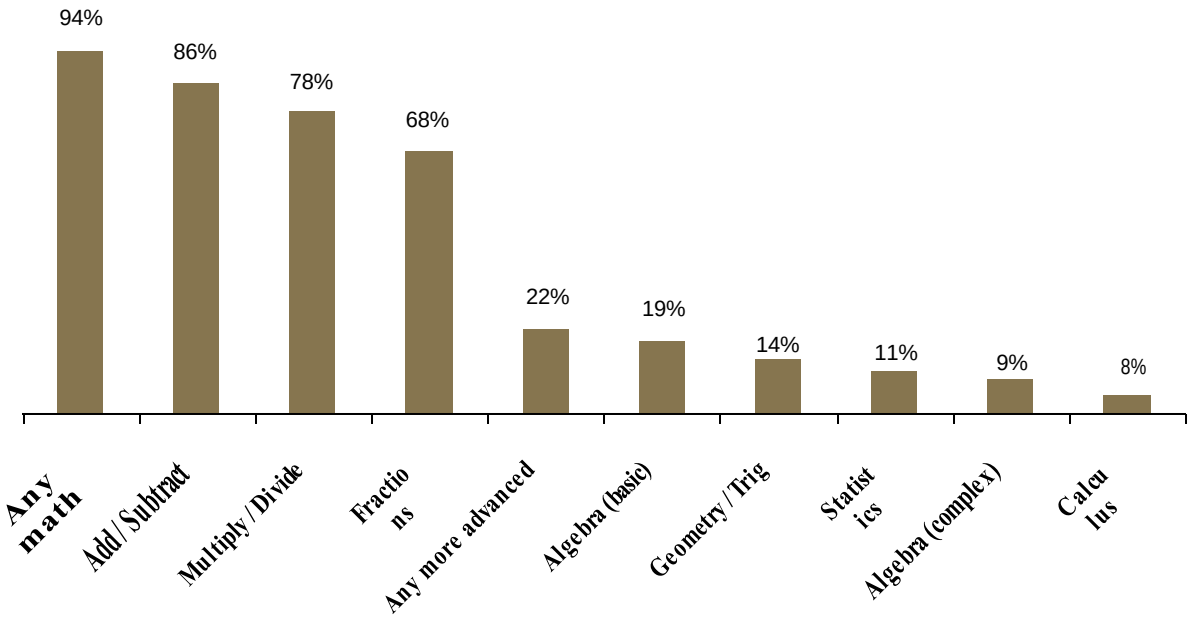
- the application of mathematical content in life-related contexts
- learners must be able to work with actual real-life problems and resources rather than with problems developed around contrived, semi-real and / or fictitious scenarios
- reasoning and communication are referred in each context and at every level
- confidence to interpret information, understand the problem, apply mathematical content and skills, reason and communicate, seem to be generally accepted skills.

In summary, it is reasonable to assert that Mathematical Literacy requires the same types and levels of problem-solving skills, using the same mathematical competencies, as 'Quantitative Literacy' ('Quantitative Literacy', Quantitative Reasoning, Functional Mathematics and Numeracy) in the international context.

WHAT IS THE DIFFERENCE BETWEEN MATHEMATICS AND MATHEMATICAL LITERACY?

While acknowledging that Mathematics as a subject is vitally important for those leaners that go on to study in the Higher Education phase in the fields of Science, Engineering and Actuarial Studies, it would seem that in the world of work the level of mathematics used is not very high. This was asserted by an American researcher in 2004-2009 (Handel, 2010) whose survey of more than 2000 workers in the USA in 2004-2006 and 2007-2009 found that less than a quarter of them used any more complicated mathematics than basic fractions and percentages in their jobs. In Figure 2 below the phrase 'any more advanced' refers to Algebra and Calculus.

Figure 2:
What percentage of Americans actually use Math at work?



Data: Michael Handel, 'What Do People Do at Work? A Profile of U.S. Jobs from the Survey of Workplace Skills, Technology and Management Practices (STAMP)'

However, what sets Mathematical Literacy apart from Mathematics as a completely different subject is how that mathematics is used. Mathematical Literacy does contain mathematical concepts, principles and knowledge. Most of this mathematics is at about the Grade 9 level, like performing numerical operations, negative numbers, calculating percentages, using ratios, drawing simple graphs, substituting into equations, working with models of linear and exponential growth, calculating statistical measures of central tendency, probability, spatial concepts like measuring and comparing values, often with different units, calculating the area of a rectangle and circle and the volumes of rectangular solids. (This list is not comprehensive.) The reason for the mathematics in Mathematical Literacy is not to learn it for its own sake. It is so that learners can use the mathematics as a tool to solve much more difficult problems all of which are authentic, relevant and commonly experienced in the lives of people in this century in South Africa. These are quantitative situations found in the home, in the workplace or in society at large, both in urban and rural contexts. The following are some of the areas that require the skills of Mathematical Literacy in the world, and particularly in the new democracy that is South Africa today. While the complete list of contexts below are quoted from Steen (2001) it is significant that the same examples are to be found in the CAPS document as areas of application of mathematical problem solving in the curriculum in South Africa. While there are no actual rural examples or contexts in Steen's list which deal specifically with indigenous knowledge in South Africa, the authors contend that all people whether rural or urban need to understand the issues listed below in order to control their own lives more successfully and avoid exploitation by those in positions of power, both politically and financially.

(i) Citizenship

- Understanding how different voting procedures can influence the results of elections
- Analysing economic and demographic data to support or oppose policy proposals
- Appreciating common sources of bias in surveys such as poor wording of questions, volunteer response and socially desirable answers

- Understanding how small samples can accurately predict public opinion, how sampling errors can limit reliability, and how sampling bias can influence results (Steen, 2001: 10)

(ii) Culture

- Recognising the power (and danger) of numbers in shaping policy in contemporary society
- Understanding how assumptions influence the behaviour of mathematical models and how to use models to make decisions (Steen, 2001: 11)

(iii) Professions

- Journalists need a sophisticated understanding of quantitative issues (especially of risks, rates, samples, surveys, and the statistical evidence) to develop an informed and sceptical understanding of events in the news
- Lawyers rely on careful logic to build their cases and on subtle argument about probability to establish or refute 'reasonable doubt'
- Doctors need both understanding of statistical evidence and the ability to explain risks with sufficient clarity to ensure 'informed consent' from patients (Steen, 2001: 12)

(iv) Personal Finance

- Calculating income tax and understanding the tax implications of financial decisions
- Estimating the long-term costs of making lower monthly credit card payments
- Understanding the different factors affecting a mortgage
- Using the Internet to make decisions about travel plans (routes and reservations)
- Understanding that there are no schemes for winning lotteries
- Choosing insurance plans, retirement plans or finance plans for buying a car or house (Steen, 2001: 13)

(v) Personal Health

- Interpreting medical statistics and formulating relevant questions about different options for treatment in relation to known risks and the specifics of a person's condition
- Understanding medical dosages in relation to body weight, timing of medication and drug interactions
- Weighing costs, benefits and health risks of heavily advertised new drugs
- Understanding terms and conditions of different health insurance policies, verifying accuracy of accounts and payments
- Understanding the impact of outliers on summaries of medical data (Steen, 2001: 14)

(vi) Management

- Developing a business plan, including pricing, inventory, and staffing for a small retail business
- Determining the break-even point for manufacturing and sale of a new product
- Gathering and analysing data to improve profits
- Reviewing the budget of a small non-profit organization and understanding relevant trends
- Calculating the time differences and currency exchanges in different countries (Steen, 2001: 14)

It is essential that there be an understanding that Mathematics and Mathematical Literacy are different subjects altogether, not just different types or levels of mathematics. The table below illustrates this.

Table 3:
Differences between Mathematics and 'Quantitative Literacy'

Mathematics	**Quantitative Literacy**
Power in abstraction	Real, authentic contexts
Power in generality	Specific, particular applications
Some context dependency	Heavy context dependency
Society independent	Society dependent
Apolitical	Political
Methods and algorithms	Ad hoc methods
Well-defined problems	Ill-defined problems
Approximation	Estimation is critical
Heavily disciplinary	Interdisciplinary
Problem solutions	Problem descriptions
Few opportunities to practice outside the classroom	Many opportunities to practice outside the classroom
Predictable	Unpredictable

Bernard Madison's table (Calculation vs Context, 2008: 11)

The link between the mathematical knowledge learned in Mathematical Literacy and the everyday contexts in which the problems are to be found is the large number of skills that are learned by doing Mathematical Literacy. The skills outlined in Table 1 above demonstrate that the range of skills in Mathematical Literacy is very wide. There are also many demanding cognitive skills and extremely complex skills. And of great importance, there is a broad set of written, oral and graphical communication skills.

Based on an in-depth study of the skills and competencies of this subject, the research team is of the opinion that these skills are not only necessary and useful for the educated person in modern society but they are also skills which equip the high-achieving Mathematical Literacy learner to cope well with Higher Education in the non-STEM (Science, Technology, Engineering and Mathematical) fields.

IS MATHEMATICAL LITERACY IN NEED OF A 'MAKE-OVER'?

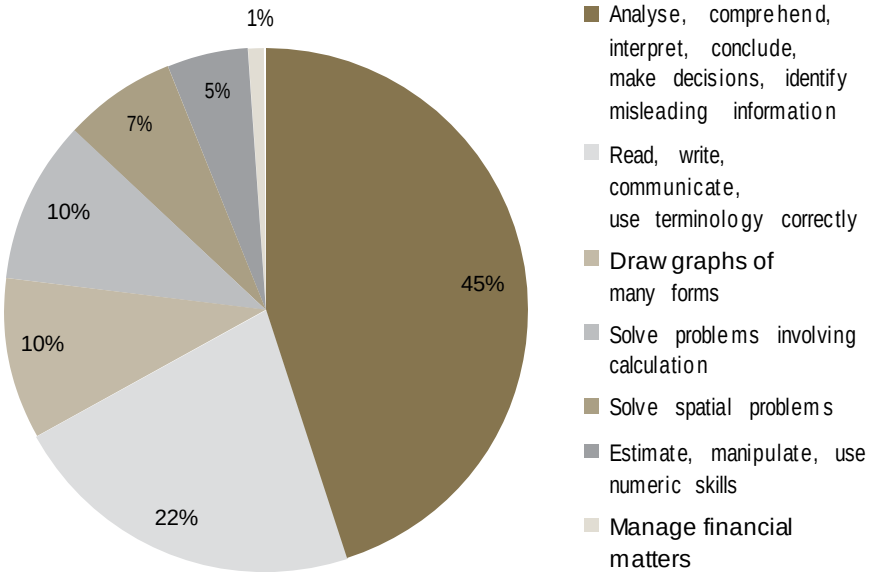
If the perception of Mathematical Literacy as second-class, poor relative of Mathematics is to be changed, then we need to consider a few important questions. The changed perception needs to be based on substance rather than ignorance or perception. It needs evidence and good reason rather than defensiveness.

(i) *Is there substance to the claim that Mathematical Literacy is cognitively demanding and can equip high-achievers for university studies?*

A recent study of the outcomes of Mathematical Literacy (based on an analysis of the CAPS document) shows that by far the largest proportion of skills required to perform well in this subject are of a high cognitive level. These are skills such as being able to interpret, analyse, draw conclusions, and make and justify decisions. Mathematical Literacy also requires a high level of communication, including reading,

writing and comprehension skills. The figure below shows the actual breakdown of exit-level skills for Mathematical Literacy.

Figure 3:
Exit-level skills for Mathematical Literacy



While acknowledging that the mathematical complexity and abstractness of Mathematical Literacy is not anywhere near the same level as mathematics, nonetheless the skills required to achieve a high performance in Mathematical Literacy are essential skills to perform well in higher education in the Humanities and Social Sciences.

(ii) What is the value of this subject?

Apart from having value as a valid admission offering for higher education, Mathematical Literacy has intrinsic value in and of itself. If taught as it should be, namely based upon authentic relevant contexts then every problem solved adds value to the life skills and ability of the learner to become an informed adult and 'to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life' (AAMT, 1997: 15). 'Mathematical literacy is reflected in habits and behaviours and ways of engaging with problems and situations' (AMESA, 2003: 2). In South Africa how many waged people understand what their net salary really represents? How many South Africans who borrow money, especially from 'Loan Sharks', actually know what rate of interest is being charged and in what time period they will need to repay the interest? Ignorance of these simple quantitative issues often results in injustice and untold suffering. Being able to understand and manage one's financial situation, whether at the very low or high end of the financial spectrum is an empowering experience and a protection from exploitation.

Increasingly, the decisions which affect our lives are being taken at government level without our consent or input. Many major national issues rest on complex quantitative arguments such as rates of growth and economic forecasts. In some popular views expressed in the media it seems that every opinion is equally valid and that when there is disagreement in civic discourse, the truth lies somewhere in the middle (Kolata, 1997). Failure to grasp the complexity of quantitative issues may lead to an ever-widening gulf between those who are quantitatively literate and those who are not.

Mathematical Literacy is the subject poised to address citizens' potential ignorance of the quantitative issues that affect their lives. What they learn in this subject may be useful ten years after leaving school

when faced with one of the many real-life situations addressed in Mathematical Literacy. Doyen and champion of Quantitative Literacy in the USA, for more than two decades, Steen (2001) is convinced that the ability to see the world through mathematical eyes, and to approach complex problems with confidence in the value of careful reasoning is essential to equip 21st century people to ask intelligent questions of experts and to confront authority confidently.

(iii) Is SA a world leader in secondary education in the teaching of Quantitative Literacy?

For the reasons explained in the background to this paper, Mathematical Literacy was introduced into secondary education in 2006 at Grade 10 level. Since then Functional Mathematics (which is similar in content and skills with Mathematical Literacy) was introduced into high schools in England in 2010 from Year 8 -11 as a *compulsory additional* subject to Mathematics for all learners. In the USA courses in Quantitative Literacy have been offered at college and university level for more than a decade. These courses contain the same mathematical skills and content and application areas as Mathematical Literacy, although, in many cases at a more complex level, particularly if the Quantitative Literacy course is offered at three successive year levels at university. However, the question is now being raised amongst mathematics educators in the USA as to whether Quantitative Literacy should be introduced at secondary school level either across the disciplines or as part of Mathematics (Steen, 2007). The conversation in the USA continues. It is clear, however, that the need is felt at secondary school level for learners to become more quantitatively literate. Will time show that the South African education system perhaps unwittingly became a world leader by introducing a subject which is extremely relevant and increasingly necessary at secondary level before it was introduced in the rest of the world?

(iv) Who should do Mathematical Literacy?

From the arguments of this paper the reader should realise that doing mathematics does not make one quantitatively literate. Even Berkeley-educated mathematician and educator, Alan Schoenfeld (2001) called his mathematics education from grade school to PhD level 'impoverished: no authentic applications, no data other than artificial numbers, no communications other than formal proofs'. By virtue of the complete distinctiveness of Mathematical Literacy as a school subject, it would make sense to make it a subject that all could take, including those doing Mathematics. Its usefulness and value in later life is without question. In terms of educative value it teaches essential skills which are transferrable and applicable across the curricula. Such an approach would enhance the perception of Mathematical Literacy by learners and the public and result in more highly skilled Mathematics learners.

MAKING A CASE FOR A NAME CHANGE OF MATHEMATICAL LITERACY IN SOUTH AFRICA

The time has come to change the name of Mathematical Literacy. The word 'Mathematical' gives the perception that it is a kind of mathematics, i.e. dumbed down to a lower level or standard grade. The word 'Literacy' is interpreted by some to refer to what small children or uneducated adults do when they learn to read. Of course this is based on ignorance of the meaning of the word 'literacy' which means 'competence or capacity'. The writers of this paper favour the name Quantitative Literacy. It is increasingly used internationally and refers to quantitative skills, some of which are non-mathematics skills, but which rely upon sense-making, reasoning and mature decision making. What a wonderful change from Maths-Lite!

CONCLUSION

The writers of this paper strongly argue that Mathematical Literacy is little understood across the public spectrum, and that it compares extremely well to international subjects taught at secondary level (in the

UK) and tertiary level (in the USA). It teaches a set of vitally important skills and dispositions which are

valuable in themselves for making sense of the highly quantitative world we live in, as well as being good preparation for higher education in the non-Science fields. Finally, as well as providing an answer to the Umalusi Council research question, we hope that this paper will be used, in different formats and in different forums, to send out a strong signal to the educators at the basic and higher levels and to the South African general public that Mathematical Literacy is not a second-rate subject worthy of derision and scorn. It is rather, a relevant, cognitively challenging and necessary subject for an educational system that purports to equip young people for higher education and the challenges of life in the 21st century.

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ANNEXURE 1: COMPARISON OF SKILLS IN THE LITERATURE REVIEW OF 'QUANTITATIVE LITERACY' (QUANTITATIVE LITERACY, QUANTITATIVE REASONING, FUNCTIONAL MATHEMATICS AND NUMERACY) AND SKILLS IN THE MATHEMATICAL LITERACY CAPS

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
Skill 1: Computational operations		
Apply arithmetic operations, using numbers embedded in print material	Analyse, interpret and understand completed tax return forms	59
	Analyse a financial statement	52
	Investigate budgets and income-and-expenditure statements	53
	Using tables and/or spreadsheets to construct a model of a loan scenario	57
	Applying operations using a large number of financial documents, e.g. household bills, shopping documents, banking documents, budgets, payslips, quotations, invoices, receipts, claim forms, tax forms and loan documentation	49
Calculator skills	Know and use the different functions on a basic calculator	21
	Use calculator to determine financial values	
	Add, subtract, multiply and divide whole numbers and decimals both with and without using a calculator, converting percentages to decimals	29, 34
	Perform simple interest calculations manually (that is, without the use of a calculator)	121
	Performing operations using numbers and calculator skills	21
	Perform simple and compound interest calculations manually using a basic calculator, pen and paper, and/or spreadsheets	55
Check the reasonableness of calculated values	Check appropriateness of a solution	26
	Check the appropriateness of a solution by comparing it to the estimated solution	21
	Determine the most appropriate form of rounding and/or number of decimal places	30
	Modify solutions as required by the context of the problem, rework problems	26

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
Computational/ Algorithmic	Use a range of techniques to determine missing and/or additional terms in a pattern, including when the formulae are provided for calculations	39
Use new technologies / Use Mathematical tools as well as ICT in sophisticated settings / Computer skills	Use science and technology effectively and critically showing responsibility towards the environment and the health of others	6
	Apply technology	8
	Operations using numbers and calculator skills	21
	Converting from percentages to decimals using a calculator	34
	Perform simple and compound interest calculations manually using a basic calculator, pen and paper, and/or spreadsheets	55
	Model loan and investment scenarios using a pen, paper, basic calculator and tables, spreadsheets, and/or available loan calculators	56
	Use tables and/or spreadsheets to construct a model of a loan scenario	57
Estimate the right order of magnitude of the solution	Recognise that the way in which data is classified, sorted and/ or grouped will affect how data is organised, summarised and represented	83
Estimation	Estimate anticipated solutions	26, 29
	Estimate values in tables and on graphs	21
	Estimated travelling distance and time and travel costs	115
	Use a given scale to estimate the distance between the two locations	124
	Estimate values from given graphs	126
	Estimate the values of the dependent and independent variables	44
	Estimate the value of a currency in relation to other currencies	60
	Estimate lengths and/or measure lengths of objects accurately to complete tasks.	64

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Estimate quantities of materials needed	79
Use of spreadsheets and creating other graphic displays on computers	Using tables and/or spreadsheets to construct a model of a loan scenario	57
	Perform simple and compound interest calculations manually using a basic calculator, pen and paper, and/or spreadsheets	54
Skill 2: Application of mathematical content		
Actively use concepts and principles	Basic ratio concepts and ratio calculations	21
	Probability concepts	95
	Using measurement concepts	62
Apply the mathematical content areas	Investigate a variety of different types of graphs in order to present a message to the reader, without getting bogged down by formal mathematical procedures	37
Applying elementary tools in sophisticated settings	Using different tools and representations that can be used to represent events involving probability in a graphical/ pictorial way	93
	Use formula to determine missing and/or additional terms in a pattern	39
	Use of formulae in perimeter, area and volume calculations	40
	Use elementary calculations in order to solve complex financial problems	57
Applying technical knowledge	Direct and inverse proportion, fixed, linear, compound growth	21, 22
	Work with variety of graphs found in newspapers, magazines and other resources	37
	Making sense of graphs that tell a story	22
Confidence to apply mathematical knowledge	Mathematically literate students should have the capacity and confidence to interpret any real-life context that they encounter	9
	Confidence in solving problems	12
	Perform any calculation involving number concepts with confidence	27
Life-related application of mathematics	Learners must be exposed to both mathematical content and real-life contexts to develop these competencies	8
	The focus in Mathematical Literacy is on making sense of real-life contexts and scenarios	8
	Mathematical Literacy involves real-life contexts	8

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Learners must be able to work with actual real-life problems and resources, rather than with problems developed around constructed, semi-real and/or fictitious scenarios	8
	Alongside using mathematical knowledge and skills to explore and solve problems related to authentic real-life contexts, learners should also be expected to draw on non-mathematical skills and considerations in making sense of those contexts	9
	The purpose of this subject is to equip learners with the necessary knowledge and skills to be able to solve problems in any context that they may encounter in daily life and in the workplace, irrespective of whether the context is specifically relevant to their lives or whether the context is familiar	9
	Demonstrate both competence in mathematical content and the ability to use a variety of both mathematical and non-mathematical techniques and/ or considerations to make sense of real-life, everyday, meaningful problems	96
	Develop the ability to use a variety of mathematical and non-mathematical techniques and/ or considerations to explore and understand both familiar and unfamiliar real-life contexts	11
	Making sense of real-life contexts and scenarios, in the Mathematical Literacy classroom mathematical content should not be taught in the absence of context	10
	Learners who are mathematically literate should have the capacity and confidence to interpret any real-life context	9
	The solving of real-life problems commonly involves the use of content and/or skills drawn from a range of topics, and so, being able to solve problems based in real-life contexts requires the ability to identify and use a wide variety of techniques and skills integrated from across a range of content topics	9

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	The confidence with which learners are able to identify and utilise appropriate mathematical content, techniques and other non-mathematical considerations in order to explore authentic real-life contexts without guidance and/or scaffolding	12
	Contexts related to scenarios involving daily life, workplace and business environments, and wider social, national and global issues that learners are expected to make sense of, and the content and skills needed to make sense of those contexts	14
	Choose two different authentic real-life scenarios involving direct proportion and inverse proportion	32
	Identify and represent a relationship in daily life	43
	Additional contexts and/or resources include any other plans in the context of the learner's daily life and in less familiar contexts relating to simple and complex structures	78
	Use authentic real-life contexts and real-life data	96
Problem-solving skills	Compare solutions to a problem expressed in different units and make a decision about what unit is the most appropriate or useful for the particular context in which the problem is posed	123
	Investigate situations in which summarised and/or represented data is interpreted in different ways	87
	Build a model and use the model in conjunction with other content, skills or applications to solve a problem	125
	Identify and solve problems and make decisions using critical and creative thinking	6
	Ability to reason, make decisions, solve problems, manage resources, interpret information, schedule events and use and apply technology	8
	Using mathematical knowledge and skills to explore and solve problems related to authentic real-life contexts	9

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	To be able to solve problems in any context that they may encounter in daily life and in the workplace, irrespective of whether the context is specifically relevant to their lives or whether the context is familiar	9
	Apply appropriate mathematical and non-mathematical techniques needed to solve problems	11
	Solve problems in scenarios involving Finance, Measurement, Maps, plans and other representations of the physical world, Data handling and Probability	21
Understanding multi-variate models	Understanding that tables, graphs and equations can all describe the same relationship, but in different ways	43
Understanding the impact of different rates of growth	Comparing rates	33
	Analyse graphs showing changes in the inflation rate over time	58
	Compare differences in the rates of change between the dependent and independent variables for each of the relationships	45
	Investigate the advantages and disadvantages of the different types of accounts regarding access to money, bank charges and interest rates	55
	Realising that inflation represents the average increase in the prices of a variety of goods and services over time and that different items can have different inflation rates	58
	Compare the rates of increase/ decrease in prices through calculation	58
	Comparing rates	33
	Represent simple interest growth scenarios using linear graphs and compound interest growth scenarios using graphs showing compound change	55
Use appropriate skills in different contexts / Grounded appreciation of the context	Mathematical Literacy develops a general set of skills needed to deal with a particular range of problems	9
	Draw on non-mathematical skills and considerations in making sense of different contexts	8
	To identify and use a wide variety of techniques and skills integrated from across a range of content topics	10

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Making sense of scenarios involving daily life, workplace and business environments and wider social, national and global issues and the content and skills needed to make sense of those contexts	13
Skill 3: Reasoning		
Analyse	Collect, analyse, organise and critically evaluate information	5
	Analyse graphs showing changes in the inflation rate over time	58
	Analyse a household bill, statement, income-and-expenditure statement	52
	Analyse the layout of the structure shown on the plan	77
Analysis of evidence	Analyse, interpret and understand completed tax return forms	59
	Analyse aspects of the layout and/or design of a structure	78
	Analyse the growth pattern of a baby/toddler	85
	Analyse data presented in graphs	85
	Analyse calculated and/or given measures of central tendency and/or spread	84
Analysis, synthesis and evaluation	Analyse problems and devise ways to work mathematically in solving such problems	8
	Analysing conclusions in terms of each stage of the statistical cycle to determine the reliability and validity of the conclusions	88
	Analysing graphs to determine trends or meaning in the data	88
	Interpret and analyse representations	43
Confidence to think numerically and spatially	Confidence in solving problems	12
	Perform any calculation involving number concepts with confidence	27
Critical thinking skills	Identify and solve problems and make decisions using critical and creative thinking	5
Draw conclusions	Conclusions should be analysed in terms of each stage of the statistical cycle to determine the reliability and validity of the conclusions	88
	Decide which average is the most representative of the majority of the data values	84
	Decide on the most appropriate procedure or method to find the solution to the question or to complete a task, and they may have to perform one or more preliminary calculations or complete one or more preliminary tasks before determining a solution	114
	Decide which method will be the most appropriate to compare the costs involved in the contracts	116
	Decide on the most appropriate representation for a given scenario	43
Evaluate the decision that those values lead to	Decide which average is the most representative of the majority of the data values	64
Evaluating risks	Use and work with situations involving probability in risk assessments	93
	Determining risk in applications for car, household and life insurance	95
	Analyse a table showing risk assessment profiles for people from different age groups and explain why particular age groups are classified as higher risks than others	127
Formulate the problem / Develop and interpret models related to problems they encounter / Determine the best analytical approach	Make decisions regarding appropriate stopping points during a journey based on considerations of fatigue, petrol consumption, travelling time, etc.	124
Guess and check / Conjecture	Check the appropriateness of a solution by comparing it to the estimated solution	21
Identify errors /Detecting fallacies	Ask questions about the way in which data has been collected, organised, summarised and represented to reveal possible sources of error/bias/ misinterpretation	87
Integrate content and cognitive processes	Patterns, relationships and representations will be integrated throughout all topics	96

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Solve problems and explore contexts relating to the topics of Finance, Measurement, Maps, plans and other representations of the physical world, Data handling and Probability, and their ability to use number concepts and equations, tables and graphs in an integrated way in order to make sense of those contexts	97
	Content and/or skills are integrated across a variety of topics throughout teaching and learning, and in the assessment activities	99
	Use of integrated content and skills drawn from different topics	98
Interpret and critically analyse in order to solve problems	Investigate and describe a variety of different types of graphs in order to develop a feeling for working with graphs and an understanding that graphs tell a story and present a message to the reader.	37
	Analyse a newspaper article describing proposed increases in electricity tariffs and make deductions about the implications of these increases for consumers	120
	Analyse graphs showing changes in income tax over different time periods and explain differences	122
	Analyse a budget for a household or business and make recommendation as to how the expenditure should be changed to improve the finances of the household/business	120
	Analyse a model and critique the layout of the structure shown in the model	125
Interpret the meaning of calculated values	Recognise and describe the meaning of different points on the graph	37
	Explain the meaning of these values in relation to the context in which the problem is posed	45
	Relevance/meaning of the break-even values	53
	The meaning of these measures in relation to the data should be determined	93
	Explain the meaning of a given scale	124
	Graphs should be analysed to determine trends or meaning in the data	88

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
Judge independently	Justify comparisons and opinions with calculations or with information provided in the context	26
	Analyse a model and critique the layout of the structure shown in the model	125
	Make suggestions for alterations	78
	Critique a proposed travel route in relation to distance, estimated travelling times, etc, and suggest and justify possible alternative routes	124
Justify	Justify comparisons and opinions with calculations or with information provided in the context	26
	Identify and solve problems and make decisions using critical and creative thinking	5
	Use knowledge of inflation rates to argue and justify a particular salary increase	121
	Critique a proposed travel route in relation to distance, estimated travelling times, etc, and suggest and justify possible alternative routes	124
	Justify comparisons and opinions with calculations or with information provided in the context	21
	Justify comparisons and opinions with calculations or with information provided in the context.	26
Make decisions / good judgements	Interpret a measured value and make a decision based on the value	123
	Analysing these graphs will make it possible to decide which contract is the better option for a certain number of minutes of talk time during a month	42
	Identify and solve problems and make decisions using critical and creative thinking	5
	Decide on the most appropriate representation for a given scenario and then construct, interpret and analyse that representation	43
	Decide on an appropriate selling price for an item and/or service based on an expected percentage profit	53

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Decide which bank would be the better option for a particular customer	55
	Decide on where to position a house or a garden in relation to the position of the sun at different times of the day	75
	Decide which average is the most representative of the majority of the data values	84
	Decide on the most appropriate procedure or method to find the solution to the question or to complete a task	114
	Decide which method will be the most appropriate to compare the costs involved in the contracts	112
	Decide on an appropriate scale in which to draw a picture or build a model, and then complete the project	124
Make sense/ engage with context	Rounding numbers depending on the context	30
	Making sense of situations involving: costs, tariffs, consumption, calculations of estimated traveling times, distance, speed, conversions and any other problems in the context of various topics.	33
	Making sense of situations involving: discount, tax, budgets, marks, estimating measurement quantities, expressions of probability	34
	Making sense of contexts and problems involving various topics	32
	Investigate and describe a variety of different types of graphs in order to develop a feeling for working with graphs and an understanding that graphs tell a story and present a message to the reader.	37
	Make sense of, participate in and contribute to the twenty-first century world	8
	Make sense of real-life contexts	8
	Explore and make sense of appropriate contexts	9
	Make sense of any context, whether the context is familiar or not	9
	Learners are expected to make sense of, and the content and skills needed to make sense of those contexts	10
	Make sense of any context or problem in which these concepts have application	36
Making or critiquing an argument	Develop opposing arguments using the same summarised and/ or represented data	88
	Critique the government's free water policy in terms of the findings of this project	69
	Evaluate and critique the validity of expressions and interpretations of probability presented in newspapers and other sources of information	94
	The learner should critique the decision	113
	Critique the scale in which an object has been drawn and offer an opinion as to a more appropriate scale	124
	Critique a proposed travel route in relation to distance, estimated travelling times, etc, and suggest and justify possible alternative routes	124
	Critique the design of a structure shown on a plan	124
	Analyse a model and critique the layout of the structure shown in the model	125
	Critique the questions/layout of a questionnaire/survey	126
	Critique the use of references to probability values in newspaper articles	127
Manage situations / Control	Organise and manage themselves and their activities responsibly and effectively	5
	Manage finances	51
	Monitor and manage mass (weight)	65
Model situations mentally and formally	Using tables and/or spreadsheets to construct a model of a loan scenario	57
	Make decisions regarding appropriate stopping points during a journey based on considerations of fatigue, petrol consumption, travelling time, etc.	124
Probe	Investigate the effect of changes in the interest rate on the loan and the impact of increasing the monthly repayment on the real cost of the loan	116

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Investigate, through research, the various costs involved in manufacturing an item, and decide on an appropriate selling price for the item	121
	Investigating impact of rounding	30
	Investigate and describe the impact of increasing the monthly repayments on the total cost of the loan/investment	121
	Investigate through calculation how the tax rebate value is determined	122
	Investigate the effect that an increase in salary has on increased tax payments	123
	Investigate and describe a variety of different types of graphs in order to develop a feeling for working with graphs and an understanding that graphs tell a story and present a message to the reader.	37
	Investigate, describe and explain shapes of graphs in relation to scenarios	32
	Investigate budgets and income-and-expenditure statements	53
Reason and think / Deductive thinking / Logical thinking /Thinking Mathematically and strategizing / Thinking with mathematics	Identify and solve problems and make decisions using critical and creative thinking	6
	Discuss reasons why a particular size for a particular grocery item may be the most cost-effective	33
	Explore the possible reasons for food price inflation and the impact of this inflation on the people who buy food from these shops	59
	Find reasons for differences in tax values calculated using tax deduction tables and tax brackets	59
	Reasoning and reflecting	109
	Calculate the mean, median and modal average for a set of data and decide with reasons which average provides the most accurate representation of the data	126
	Ability to reason, make decisions, solve problems, manage resources, interpret information, schedule events and use and apply technology	8
Reason in numerical, data, spatial and chance settings	Reasoning, determining and discussing the most cost-effectiveness	33

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
Seeing connections	Make connections between plans	124
	Connect the features shown on elevation plans with features and perspectives shown on a floor plan of the same structure	77
Understand	Interpret, understand and use different numbering conventions	28
	Understand situations and solve problems in scenarios involving Finance, Measurement, Maps, plans and other representations of the physical world, Data handling and Probability	21
	Understanding graphs that tell a story	22
	Interpret, understand and use different numbering conventions in contexts	28
	A proper understanding of the problem should be developed	30
	Rounding numbers with a proper understanding	30
	Perform calculations with an understanding	31
	Understand situations involving cost, tariffs, consumption, discount, tax budgets, market, etc	33-34
	Understanding relationships	41
	Understanding that tables, graphs and equations can all describe the same relationship, but in different ways	43
Validate	Analyse a payslip and show how the values on the payslip have been determined, including the UIF	59
	Prepare a budget to show the projected cost of painting the classroom	78
	Use a given formula to show how the amount charged for electricity consumption shown on the bill has been determined	120
	Draw graphs, without scaffolded or guiding questions, to show the costs involved in producing an item and money generated from the sale of the item	121
Skill 4: Statistical application		
Ask the right questions about data	Ask questions about the way in which data has been collected, organised, summarised and represented to reveal possible sources of error/bias/ misinterpretation	87

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
Assess the quality of the information, assessing claims	Analysing conclusions in terms of each stage of the statistical cycle to determine the reliability and validity of the conclusions	88
	Assessing products making statements regarding probability	91
	Recognise that error in measurement can make a large difference to an answer	26
	Recognising the possible effect of rounding values within a calculation on the final calculated answer	29
	Ask questions about the way in which data has been collected, organised, summarised and represented to reveal possible sources of error/bias/ misinterpretation	87
Drawing inference from data	Learner is required to make inferences	116
Engage meaningfully with personal, social and political issues	Relate to daily life, the workplace and the wider social, political and global environments	8
Find information	Collect, analyse, organise and critically evaluate information	5
	Visit a supermarket and record pricing and size/weight/volume information for different grocery items	33
	Collect pricing information on a similar type of savings account at different banks	55
Interpret data	Interpret graphs representing situations involving direct and inverse proportion	32
	Interpret and analyse representations	43
Predict	Probability in weather predictions	24
	Probability in games with coins and dice, and weather predictions	24
	Analyse inflation figures to predict possible adjustments to building costs	78
	Making predictions about the outcome of an event	92
	Predict the trend of an outcome over a long period of time	92
	Recognise the difference between predictions that are based on knowledge and intuition about a situation	92
	Predict with certainty what the outcome of the match will be	93
	Decision, opinion or prediction about a particular scenario based on calculations in a previous question or on given information	116
Process, respond and think about numeric, quantitative, spatial, statistical, mathematical information	Investigate and describe a variety of different types of graphs in order to develop a feeling for working with graphs and an understanding that graphs tell a story and present a message to the reader.	37
Recognise the difference between correlation and causation		
Recognise the difference between randomised experiments and observational studies		
Statistical reasoning	Make a deduction about whether collected information is biased or valid based on the structure of instrument used to collect the data and the way in which the data was collected	126
	Explain with justification whether data is discrete or continuous	126
	Analyse data organised in tables and make deductions about trends in the data	126
	Analyse a table, graph or chart and explain or critique the use of probability values	127
Understand, predict and control situations important to their lives	Analyse inflation figures to predict possible adjustments to building costs	78
	Making predictions about the outcome of an event	92
	Predict the trend of an outcome over a long period of time	92
	Recognise the difference between predictions that are based on knowledge and intuition about a situation	92
	Predict with certainty what the outcome of the match will be	93
	Decision, opinion or prediction about a particular scenario based on calculations in a previous question or on given information	116

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Interpret, understand and use different numbering conventions	28
	Understand situations and solve problems in scenarios involving Finance, Measurement, Maps, plans and other representations of the physical world, Data handling and Probability	21
	Understanding graphs that tell a story	22
	Interpret, understand and use different numbering conventions in contexts	28
	A proper understanding of the problem should be developed	30
	Rounding numbers with a proper understanding	30
	Perform calculations with an understanding	31
	Understand situations involving cost, tariffs, consumption, discount, tax budgets, market, etc	33-34
	Understanding relationships	41
Weighing evidence / Compare	Decide which method will be the most appropriate to compare the costs involved in the contracts	116
	Compare solutions to a problem expressed in different units and make a decision about what unit is the most appropriate or useful for the particular context in which the problem is posed	123
	Comparing prices, data values in tables and on a graph	33, 34
	Comparing two different items	35
	Determining cost-effectiveness	33
	Conduct an experiment to compare the experimental probability of an event to its theoretical probability	127
	Compare differences in the rates of change between the dependent and independent variables for each of the relationships	45
	Compare different representations of multiple sets of data and explain differences	87
	Compare the probability values for two experiments	95
	Using calculations to compare income and expenditure values for a business in order to determine whether the business is in a healthy financial position	116
	Comparing bank charges on two different types of accounts for various transactions and making a decision about the most suitable account for an individual with particular needs	116
	Constructing a table to model a loan scenario, taking into account the interest calculated on the loan, the monthly repayment and the closing balance on the loan every month	116
	Using the model of the loan scenario to investigate the effect of changes in the interest rate on the loan and the impact of increasing the monthly repayment on the real cost of the loan	116
	Designing two different types of boxes for packaging an item, comparing the boxes in terms of wasted space (volume) and materials (surface area), and making a decision about the most cost-effective box for packaging the item	116
Skill 5: Communication		
Communicate findings visually, verbally, orally	Communicate solutions using appropriate terminology, symbols and units	21
	Communicate effectively using visual, symbolic and/or language skills in various modes	5
	Communicate decisions using terminology (both mathematical and non-mathematical) appropriate to the context	9
	Clearly state workings and methods used for solving a problem	
	Investigating, understanding and describing graphs using every day and/or familiar terminology	37
	Explain shapes of graphs in relation to scenarios	32
Communicate simple quantitative ideas in English	Communicate effectively using visual, symbolic and/or language skills in various modes	5
	Complete the task presented in the instructions and/or explain what the instructions mean and/ or represent, using everyday language	76
	Communicate decisions using terminology (both mathematical and non-mathematical) appropriate to the context	9
Communicate what Mathematics reveals	Communicate decisions using terminology (both mathematical and non-mathematical) appropriate to the context	9

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
Communication	Communicate effectively using visual, symbolic and/or language skills in various modes	5
	Complete the task presented in the instructions and/or explain what the instructions mean and/ or represent, using everyday language	76
	Communicate decisions using terminology (both mathematical and non-mathematical) appropriate to the context	9
Construction, communication and evaluation of arguments	Develop opposing arguments using the same summarised and/ or represented data	88
Interpret, apply and communicate mathematical information	Investigating, understanding and describing graphs using every day and/or familiar terminology	37
	Investigate and describe a variety of different types of graphs in order to develop a feeling for working with graphs and an understanding that graphs tell a story and present a message to the reader.	37
	Interpreting and analysing data	88
	Interpret newspaper articles, real bank statements, real plans and other authentic resources, rather than contrived problems containing only a semblance of reality	108
	Interpret graphs showing the cost of production and income generated from the production and sale of an item, and use the graphs to make decisions about the business	121
	Interpret time values on a bus timetable to determine departure, arrival and travelling times	123
	Devise and apply both mathematical and non-mathematical techniques and considerations in order to explore and make sense of any context, whether the context is familiar or not	9
	Apply addition and multiplication facts	29
	Communicate solutions using appropriate terminology, symbols and units	21
	Communicate effectively using visual, symbolic and/or language skills in various modes	5

Skill described in literature review of 'Quantitative Literacy'	Skill described in Mathematical Literacy CAPS	CAPS Page Reference
	Communicate decisions using terminology (both mathematical and non-mathematical) appropriate to the context	9
Language, reading and comprehension / Read, write and engage with numerical information	Describing graphs using every day and/or familiar terminology	37
	Read through and answer questions relating to the Tax Pocket Guide brochure issued by SARS	50
	Read information directly from a given questionnaire/survey	126
Representation	Representing and comparing data values in tables and graphs	34
	Representations of relationships in tables, equations and graphs	41
	Representing data	86
	Representations for determining possible outcomes	93
	Interpret graphs representing situations involving direct and inverse proportion and illustrating the difference between the two types of proportion	32
	Draw graphs to represent different scenarios	32
	Representing and/or comparing data values in tables and on a graph	34
Use written and graph source material	Investigate and describe a variety of different types of graphs in order to develop a feeling for working with graphs and an understanding that graphs tell a story and present a message to the reader.	37
Verbal / Interpretive	After interpreting the floor plans of a house, build a scale model and perform perimeter, area and volume calculations in the context of fencing, paint, concrete, etc.	78
	Interpreting and analysing data	82
	Interpret quartile values, inter-quartile range values, and box-and-whisker diagrams in order to make deductions regarding trends in the data	85
	Interpret and read values from a pie chart and, if necessary, explain how the sizes of the different segments of a pie chart have been determined	86
	Interpret the plot and explain what the shape of the plot signifies in terms of the spread of the data values	86

ANNEXURE 2: A COMPARISON OF THE MATHEMATICAL KNOWLEDGE/CONTENT IN 'QUANTITATIVE LITERACY' AND THE MATHEMATICAL KNOWLEDGE/CONTENT IN THE CURRICULUM AND ASSESSMENT POLICY STATEMENT FOR MATHEMATICAL LITERACY IN SOUTH AFRICA.

	CAPS	Literature review of 'Quantitative Literacy'
Basic skills	Interpreting and communicating answers and calculations	
	Numbers and calculations with numbers	Arithmetic/numeric calculations, Proportional reasoning, e.g. in ratio problems
	Patterns, relationships and representations	Linear and exponential graphs, Pattern recognition, Variables and relations, Solving non-linear equations, Working with models of linear and exponential growth
Application topics	Finance	Production rates and price schemes
	Measurement	Extrapolation and fitting lines or curves to data, Area of rectangle and circle and volume of rectangular solids, spheres, cylinders and cones, Measurement
	Maps, plans and other representations	Space and visualisation
	Data handling	Recording data, Statistical analysis (measures of central tendency and dispersion
	Probability	Probability, Combinatorics, e.g. combinations and permutations, expressed in tree diagrams and useful in probability