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HIGHER EDUCATION
SOUTH AFRICA

access and entry level benchmarks the national benchmark tests project

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edited by Hanlie Griesel

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Acronyms and Abbreviations

AARP	Alternative Admissions Research Project
AL	Academic literacy
ALL	Adult Literacy and Lifeskills survey
APA	American Psychology Association
BICS	Basic Interpersonal Communicative Skills
CALP	Cognitive Academic Language Proficiency
CAMP	Cognitive Academic Mathematical Proficiency
CAO	Central Applications Office
CHED	Centre for Higher Education Development
CRTs	Criterion-referenced tests
CTP	Committee of Technikon Principals
DIF	Differential item functioning
DoE	(National) Department of Education
EFPA	European Federation of Psychological Associations
ETS	Educational Testing Service
FET	Further Education and Training
HDIs	Historically Disadvantaged Institutions
HE	Higher Education
HEAIDS	Higher Education HIV and AIDS programme
HELM	Higher Education Leadership and Management programme
HESA	Higher Education South Africa
IELTS	International English Language Testing Service
ITC	International Test Commission
LO	Learning Outcome
MB	Matriculation Board
MSEB	Mathematical Sciences Educational Board
NAEP	(US) National Assessment of Educational Progress
NBTs	National benchmark tests
NBTP	National Benchmark Tests Project
NCHE	National Commission on Higher Education
NiSHE	National Information Service for Higher Education
NLS	New Literacy Studies
NQF	National Qualifications Framework
NRTs	Norm-referenced tests
NSC	National Senior Certificate
PISA	Programme for International Student Assessment
QA	Quality Assurance
QL	Quantitative literacy
SADC	Southern African Development Community
SAT	Scholastic Achievement Test
SATAP	Standardised Assessment Tests for Access and Placement
SAUVCA	South African Universities Vice-Chancellors Association
SC	(current) Senior Certificate
TEEP	Test in English for Educational Purposes
TELP	Tertiary Education Linkages Project
TIMSS	Trends in International Mathematics and Science Study
TOEFL	Teaching of English as a Foreign Language

Preface

The idea of national benchmark tests reaches back to the mid-2004. A set of proposals was discussed and agreed upon by the leadership of public higher education within the broad vision of building a responsive enrolment system.

Yet the reasons for "benchmarking" entry level proficiencies are often misconstrued or misunderstood. The purpose of this publication is therefore to describe in some detail the reasons for and context of the National Benchmark Tests Project, what benchmark tests entail, and the frameworks that will shape the development of tests in academic and quantitative literacies, and mathematical proficiency.

As authors observe in this publication, the development of benchmark tests is complex and will continue to require the support and goodwill of experts and institutions. But the potential value is undoubtedly enormous and there is every reason to believe that high quality national benchmark tests can realistically be achieved by 2008.

In the South African context the changing interface between schooling and higher education demands of both sectors to re-examine curricula, approaches to assessment and, indeed, the degree of fit between the outcomes of schooling and the entry requirements of higher education (or, for that matter, the world of work).

The project represents an attempt to provide both schooling and higher education with important information on the competencies of their exiting (in the case of schools) and entering (in the case of universities) students; information that does not duplicate the essential information delivered by the school-leaving examination, but that provides an important extra dimension.

Who gains access and to which levels of study will remain high on the agenda of this society and its diverse range of higher education institutions – universities, comprehensive universities and universities of technology. At present approximately one in five school-leavers gains entry; yet we simultaneously recognise that access must reach beyond mere entry and must also entail students' successful engagement with the demands of "higher" studies.

Professor Brian O'Connell
Vice-Chancellor and Principal, University of the Western Cape &
Chair of the HESA Enrolment Steering Committee

1

THE CONTEXT OF THE NATIONAL BENCHMARK TESTS PROJECT

Hanlie Griesel
Higher Education South Africa (HESA)

Overview

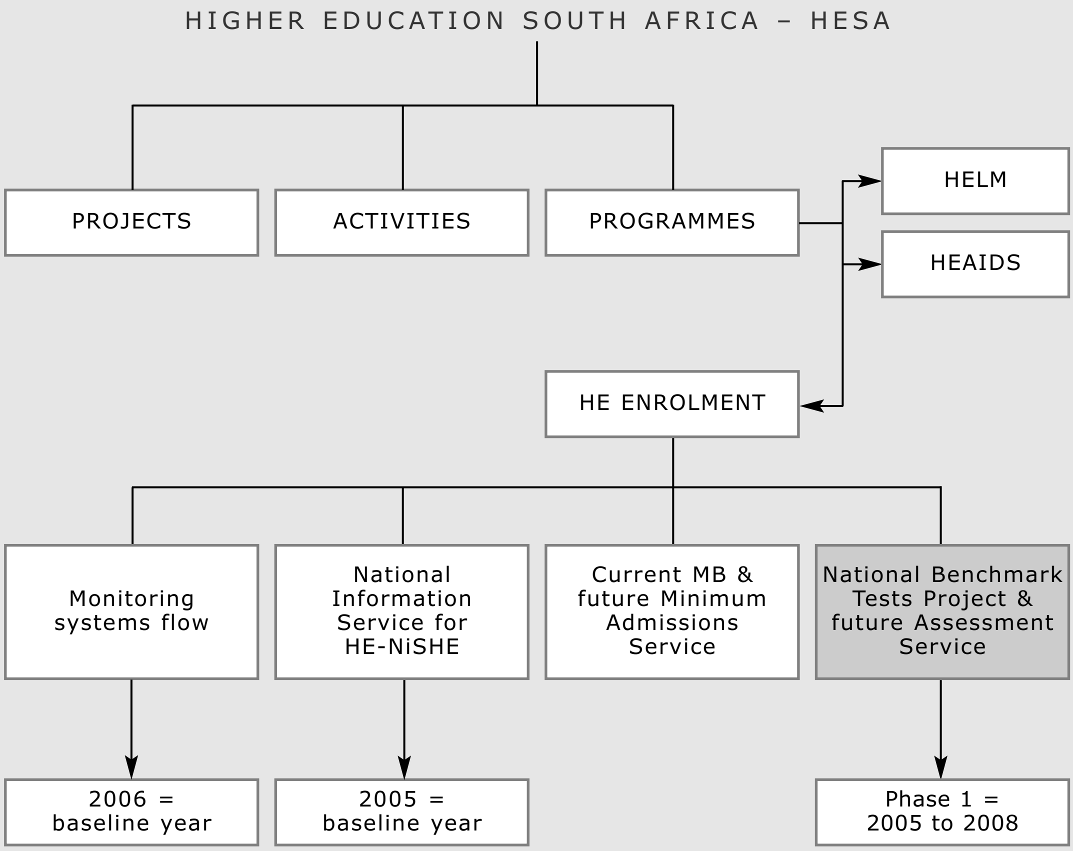
The impetus for the development of national benchmark tests is located in a complex of policies, a changing schooling-higher education interface and the realities of a restructured higher education (HE) landscape and changing institutional profiles – all factors which in one way or another impact upon access and the practices associated with higher education enrolment.

By mid-2004 the vision for distinct yet interrelated sector-level enrolment services was well established; services that will entail:

- An information service that sends a clear message to schools, FET colleges, parents and the public on the role of higher education in preparing students for future careers, what is on offer and what is expected at entry levels;
- An admissions service that regulates minimum thresholds for entry into higher education study; and
- An assessment service that benchmarks entry levels in order to inform both admission and placement practices and curriculum responsiveness.

In 2005 a further project was initiated: Monitoring systems flow in terms of enrolment, throughput/retention and graduation in order to provide accurate information and analyses on system flow, efficiencies and strategic sector action that may be deemed necessary.

Hesa's Enrolment Services Programme



It is in the context of this broad vision and the specific consequences of a changing schooling-higher education interface that Vice-Chancellors approved the proposal for the establishment of the National Benchmark Tests Project (NBTP) in the General Meetings of the then South African Universities Vice-Chancellors Association (SAUVCA) and the Committee of Technikon Principals (CTP). Institutions were subsequently invited to nominate assessment specialists in the areas of academic literacy and numeracy/mathematics to participate in the project. The first national meeting with institutional representatives was held on 25 November 2004, the central purpose to lay the foundations of the project and build a common understanding of the task ahead.

An initial core team or strategy group was appointed and the next phase of development became focused on the development of pilot tests by specialist test development teams (see Section 2, page 15 for a more detailed description). In parallel, the two related sector-level enrolment services have continued their development in line with what is now known as HESA's Enrolment Services Programme. The diagram on the opposite page illustrates.

The idea of a responsive higher education enrolment system offering a range of services to students, institutions and the sector reaches back to the access imperatives of the late 1980s and early 1990s, and the concern with equity and quality of opportunity. Subsequently these imperatives have found expression in a range of policy documents and planning frameworks, most notably the National Commission on Higher Education (NCHE, 1996); The White Paper 3, *A Programme for the Transformation of Higher Education* (July 1997); and the more recent *National Plan for Higher Education* (2001).

Two particular policies in the past year have created further impetus for the kinds of services that make up HESA's enrolment programme:

- The policy on Minimum Admission Requirements for Higher Certificate, Diploma and Degree Programmes requiring the National Senior Certificate (August 2005); and
- The amended policy on the new schools curriculum for Grades 10-12 and the National Senior Certificate: A Qualification at Level 4 on the NQF (July 2005).

Further, and at a macro level, the enrolment management planning framework developed by the Department of Education in early 2005 compels higher education to develop a responsive enrolment system for the sector.

The services

In outline, the nature of the distinct yet interrelated HESA enrolment services can be captured as follows:

National Information Service for Higher Education – NiSHE

In addressing the dearth of information and career counselling available in the majority of schools and broader society, NiSHE was established in 2005 with a two-fold strategic objective:

- To provide information and guidance on the role and requirements of higher education in South Africa to learners at schools, teachers, parents, FET colleges and prospective higher education students; and
- To link higher education programme and qualification pathways to future career directions and possibilities.

In its first year of operation the focus was on materials for Grade 9 as well as Grades 11-12 learners; in 2006 the focus has shifted to the development of a vibrant data-driven website that will become the source for future materials development.

In addition, a data system will be developed to monitor systems flow in terms of enrolment, retention and graduation rates.

The Matriculation Board and future Minimum Admissions Service

The Matriculation Board and future Minimum Admissions Service will continue to fulfil the statutory function of regulating minimum thresholds to first degree study, in terms of current regulations; and to certificate, diploma and degree study, in terms of the interim transition policy under development and the new policy on minimum admission requirements that will come into effect in 2008/9.

Its current services entail:

- Certifying applications for exemption from the matriculation endorsement requirements;
- Benchmarking foreign and SADC qualifications and maintaining international country profiles; and
- Providing advisory services to schools, parents and HE institutions.

It is envisaged that these services will continue with the phasing in of the new school-leaving exit qualification from 2008 onwards, and in future will also be available to private HE institutions.

The National Benchmark Tests Project (NBTP) and future Assessment Service

The purpose of the NBTP is four-fold:

- To assess entry-level academic and quantitative literacy and mathematics proficiency of students;
- To assess the relationship between entry level proficiencies and school-level exit outcomes;
- To provide a service to HE institutions requiring additional information in the admission and placement of students; and
- To inform the nature of foundation courses and curriculum responsiveness.

The pilot phase of the project is underway and its management and development is outsourced to the Centre for Higher Education Development (CHED) at the University of Cape Town (see Section 2).

It is anticipated that by early 2007 the project will be able assess entry level proficiencies across the HE system, and that by 2008 the test development phase will be completed and an assessment service can be offered to individuals and institutions to aid the process of fair and accurate admission and placement decisions.

In summary, the overall goal of the distinct yet interrelated services is clear: to develop responsiveness to the different challenges entailed in access and the consequences of a changing schooling-HE interface.

It seems necessary, however, briefly to take stock of the challenges related to access and entry-level testing.

The challenges

There are at least three assumptions and conditions which underpin the need for benchmarking entry level proficiencies to higher education study:

- Where school-leaving results are an inaccurate reflection of the knowledge, skills and applied competencies of students – or an inadequate reflection of their "potential" (i.e. future) intellectual ability – it is necessary to develop additional forms of assessment in order accurately and fairly select and place students. And in order to be both accurate and fair, test development and the interpretation of results need to be informed by specific constructs, psychometric qualities and standards or benchmarks (see Sections 2 and 3).

- If HE curricula are to be responsive to the needs of a changing profile of students, higher education ought to have a full grasp of the nature of preparedness – and the varying levels of under-preparedness – of entry cohorts, and what this diversity means in terms of the educational tasks of individual institutions and the HE system as a whole.

- Given the variability of school-leaving results and the reality of a new schools curriculum and exit qualification which have as yet not been "benchmarked" against comparable (international and local) qualifications, it seems necessary for higher education to set minimum entry thresholds and to assess levels of proficiency, at least until such time as the implementation of the new curriculum and National Senior Certificate have stabilised.

The first condition has resulted in the development of a range of assessment protocols in the South African higher education context, specifically over the past two decades. The National Benchmark Tests Project deliberately wants to pool this expertise, even though it is recognised that expertise is by no means evenly spread across the sector. Further, while different theoretical frameworks and assessment practices have shaped the expertise developed within the sector, a similar discourse seems to be in use, especially with regard to assessment being linked to the policy goal of increased participation and broadened access. This apparent "sameness" obscures important differences, however.

The challenge is therefore both to de-construct our taken-for-granted assumptions about assessment and access to higher education studies, and to re-construct a common understanding that will inform the National Benchmark Tests Project.

The second assumption is that we need an accurate assessment of entry levels in order to inform institutions' understanding of and response to the nature of entry cohorts, including the varying levels of "preparedness" that must responsibly be addressed in first year curricula and foundation courses, in particular. Too often we underestimate the reality of higher education's limited window of opportunity to develop the kinds of graduates required by a 21st century world of work. The fact remains – and needs continually to be restated – that higher education must build on the foundation created by the education and training opportunities which precede students' progression into higher education.

The third condition is perhaps the crux of our current problem: if the current Senior Certificate were a stable index of levels of achievement and proficiency, higher education may not have needed to develop "alternative" forms of assessment. And if the proposed National Senior Certificate (NSC) had been "benchmarked" against comparable qualifications, there indeed may also not have been the need for higher education to develop entry level benchmarks. While the NSC shows much promise in addressing many of the deficiencies in the current Senior Certificate (SC), the fact remains that this promise needs to be translated into practice. Until the first cohort of NSC learners has completed higher education studies, the predictive validity of this exit qualification remains a promise on paper and not an empirical reality.

Concluding comment

The task at hand is certainly challenging and its success will continue to require the support and goodwill of all the experts and institutions involved. Section 2 describes in some detail the nature of benchmark tests and the steps entailed in test development, while Section 3 focuses on the test domains and constructs which guide item development.

There is no doubt that the end product of the NBTP will be a valuable addition to the tools currently available to guide admissions decision-making and programme placement at HE institutions in South Africa. In addition – and given that access to HE studies will remain high on the agenda of HE institutions – it is anticipated that the NBTP will both inform HE curricula and teaching and learning practices, as well as provide "2nd chance" entry opportunities to those whose school-leaving results prevent them from gaining access to higher education study.

There is also no doubt that the NBTP will strengthen HESA's enrolment services and, at a national systems level, increase the sector's responsiveness to the different challenges entailed in access and the consequences of a changing schooling-HE interface.

2

THE NATURE OF BENCHMARK TESTS

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What is a benchmark test?

In trying to define the concept "benchmark tests", it is important that the terms "benchmark" and "test" be defined separately before contemplating their joint meaning.

The first question to tackle is, "What is a benchmark?" In educational settings, a **benchmark** is a point of reference for evaluating and monitoring the adequacy of the achievement and educational development of learners. The following illustrates:

> Benchmarks should be thought of as a collection of references for evaluating the growth of individual students. Benchmarks do not put a ceiling on that growth, limit the growth to a narrow band of intellectual activities, or suggest that performance at a lower level means failure. Benchmarks represent a growth model of learning. (Larter, 1991: 5)

It is important to note that sets of desired learning outcomes, such as those found in the subject statements of the new schools curriculum for Grades 10-12, are sometimes referred to as "content" standards. This is because the outcomes are related to the typical educational progress through a content domain (learning area or subject). However, such outcomes do not provide performance standards (benchmarks) as they do not specify what the minimum expected levels of achievement should be by the time that the learner reaches a particular grade level. The learning outcomes provide us with a range of learning outcomes that could be achieved according to differing levels of complexity. Some learners could achieve the first level of complexity of an outcome, while others could achieve more advanced levels of an outcome.

In contrast, performance standards (benchmarks) provide us with the expected level of attainment of the learning outcomes that *all* learners *should* reach by certain grade levels. An example of the benchmarks set for Science Literacy (with respect to the Structure of Matter) is provided in Table 1 below.

Table 1

The Benchmarks for Science Literacy (Structure of Matter) Outcomes Expected at Particular Grade Levels[1]

End of 12th grade (all students should know that):

- Atoms are made of a positive nucleus surrounded by negative electrons. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms form bonds to other atoms by transferring or sharing electrons.
- The nucleus, a tiny fraction of the volume of an atom, is composed of protons and neutrons, each almost two thousand times heavier than an electron. The number of positive protons in the nucleus determines what an atom's electron configuration can be and so defines the element. In a neutral atom, the number of electrons equals the number of protons. But an atom may acquire an unbalanced charge by gaining or losing electrons.
- Neutrons have a mass that is nearly identical to that of protons, but neutrons have no electric charge. Although neutrons have little effect on how an atom interacts with others, they do affect the mass and stability of the nucleus. Isotopes of the same element have the same number of protons (and therefore of electrons) but differ in the number of neutrons.

End of 8th grade (all students should know that):

- All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any element are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.
- Equal volumes of different substances usually have different weights.
- Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions.

End of 5th grade (all students should know that):

- Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions.
- No matter how parts of an object are assembled, the weight of the whole object made is always the sum of the parts; and when a thing is broken into parts, the parts have the same total weight as the original thing.
- Materials may be composed of parts that are too small to be seen without magnification.
- When a new material is made by combining two or more materials, it has properties that are different from the original materials. For that reason, a lot of different materials can be made from a small number of basic kinds of materials.

End of 2nd grade (all students should know that):

- Objects can be described in terms of the materials they are made of (clay, cloth, paper, etc.) and their physical properties (color, size, shape, weight, texture, flexibility, etc.).
- Things can be done to materials to change some of their properties, but not all materials respond in the same way to what is done to them.

Masters and Forster note that benchmarks can be either comparative or absolute (1996a: 49):

- **Comparative** benchmarks (or norm-referenced benchmarks) are set with reference to the achievements of others (e.g., to the performance of learners in previous years, in different provinces, or in other countries).

- **Absolute** benchmarks, or performance standards, are set at a desired level of performance on a criterion (or content domain) for a specific purpose. For example, in educational settings, absolute benchmarks or standards are set in terms of what the minimum level of knowledge and skill should be that is required of learners in Grade 9, Grade 12, or at entry to higher education studies.

With the above delineation of "benchmark" in place, the second concept that needs defining is that of a "test". Broadly speaking, in educational assessment a **test** provides a sample of behaviour or a content domain (cf. Foxcroft & Roodt, 2005). From this sample, inferences are made regarding the level of performance of an individual or a group. A test is usually administered under standardised (controlled) conditions and systematic procedures are used to score it and to interpret test performance.

There are various types of tests. Tests inter alia vary according to what they assess (e.g., intelligence, personality, achievement in mathematics), the assessment mode used (e.g., paper-based, computer-based, performance-based), whether they are administered individually or in a group context, and how they are interpreted (e.g., scores are compared to a norm group or are interpreted with respect to the level achieved on the criterion of interest). With reference to the latter aspect, a discussion on the use of norm-referenced and criterion-referenced tests (CRTs) when assessing educational achievement is pertinent when trying to conceptualise benchmark tests.

In **norm-referenced tests** (NRTs), test scores are compared to those of a reference or norm group (e.g., age, grade or gender groups) and performance is interpreted as being below average, average, above average, etc. with respect to the norm group. The use of norm-referenced tests in achievement testing has been increasingly criticised on the basis that they are biased against culturally different and English Second Language or bilingual learners and that they provide little information that can guide the facilitation of learning and educational programme planning and development (Stratton & Grindler, 1990).

In educational testing, **criterion-referenced tests** (CRTs) are constructed to provide information about the level of a test-taker's performance in relation to clearly defined domain of content and/or behaviours (e.g., reading, writing, mathematics) that requires mastery. These criteria are usually stated as performance objectives (learning outcomes). Test scores are associated with **performance categories** such as "developing", "expanding", and "advanced", each containing a thick (detailed) description of what learners whose performance falls in the category know and can do. Such performance information can be used to individually-tailor learning programmes, for example. Table 2 contains the performance categories and the corresponding scores on the reading achievement test of the US National Assessment of Educational Progress (NAEP). Positions along the performance continuum are indicated by numbers that range from 0 to 500, which are divided into five levels (performance categories), namely, Rudimentary (0-150), Basic (151-200), Intermediate (201-250), Adept (251-300), and Advanced (301-500).

[1] The benchmarks were developed by the American Association for the Advancement of Science (1995: XI) and represent statements of what all learners should know and be able to do in various aspects of science by the end of Grades 2, 5, 8, and 12.

Table 2

Performance Continuum and Categories for the NAEP Reading Achievement Test[2]

Advanced (test score range : 301-350) Readers who use advanced reading skills and strategies can extend and restructure the ideas presented in specialized and complex texts. Examples include scientific materials, literary essays, historical documents, and materials similar to those found in professional and technical working environments. They are also able to understand the links between ideas even when those links are not explicitly stated and to make appropriate generalizations even when the texts lack clear introductions or explanations. *Performance at this level suggests the ability to synthesize and learn from specialized reading materials.*
Adept (test score range : 251-300) Readers with adept reading comprehension skills and strategies can understand complicated literary and informational passages, including materials about topics they study at school. They can also analyze and integrate less familiar material and provide reactions to and explanations of the text as a whole. *Performance at this level suggests the ability to find, understand, summarize, and explain relatively complicated information.*
Intermediate (test score range : 201-250) Readers with the ability to use intermediate skills and strategies can search for, locate and organize the information that they find in relatively lengthy passages and can recognize paraphrases of what they have read. They can also make inferences and reach generalizations about main ideas and author's purpose from passages dealing with literature, science, and social studies. *Performance at this level suggests the ability to search for specific information, interrelate ideas, and make generalizations.*
Basic (test score range : 151-200) Readers who have learned basic comprehension skills and strategies can locate and identify facts from simple informational paragraphs, stories, and news articles. In addition, they can combine ideas and make inferences based on short, uncomplicated passages. *Performance at this level suggests the ability to understand specific or sequentially related information.*
Rudimentary (test score range 0-150) Readers who have acquired rudimentary reading skills and strategies can follow brief written directions. They can also select words, phrases, or sentences to describe a simple picture and can interpret simple written clues to identify a common object. *Performance at this level suggests the ability to carry out simple, discrete reading tasks.*

In addition to performance categories (levels) along a continuum, **minimum performance standards (benchmarks)** can be set on the performance continuum and the test score scale so that test-takers who obtain scores below this standard are considered to have a definite weakness that requires intervention as they have not been able to achieve the expected minimum level of proficiency.

When the aim is to benchmark test performance in a content domain against a point along a performance continuum, CRTs are considered to be more appropriate than norm-referenced tests.

By synthesising what a benchmark and a criterion-referenced test is, the following **working definition** of a benchmark test can be derived:

[2] Adapted from Masters & Forster, 1996b: 66.

Benchmark tests assess performance with respect to learning outcomes (content standards) in a specific content domain (subject, learning area) along a continuum on which the expected level of minimum proficiency (benchmarks/performance standards) has been set for a specific purpose (e.g., entry into higher education).

Steps in developing benchmark tests

As criterion-referenced tests (CRTs) are more appropriate to use when setting benchmarks, the description of the steps in developing a benchmark test is closely aligned with the development of CRTs.[3]

The steps in developing and researching benchmarks tests can be divided into three broad phases, namely:

1. Planning;
2. Field testing, psychometric evaluation and standard setting; and
3. Finalisation of the test and ongoing evaluation.

Below follows a brief outline of specific steps in each phase with attention to how each step will be implemented in developing and researching the NBTs.

1. Planning Phase

Test Development	Research Activities
Initial planning: 1. Specify the purpose of the test and the domains and/or behaviours of interest. (See Section 3 for the purpose of the NBTs and the domains to be tapped.) 2. Target group: The NBTs will be administered to learners entering HE. 3. Estimate of test length: Approximately 3 hours. 4. Available expertise: Has been and continues to be scoped. 5. Financial resources: A budget has been drawn up for the NBTs and some funding has been secured. 6. Schedule: A schedule has been compiled to complete the development and validation of the NBTs by 2008.	▪ Review research related to the development of CRTs to guide the NBT test development process.
Review each content domain: This entails reviewing and finalising the description of the content domain and performance categories (objectives/ outcomes) to be included in the NBTs (see Section 3), as well as preparing test specifications for each content domain and reviewing them for completeness, accuracy, clarity and practicality.	▪ Undertake literature scoping of the content domains, performance categories and test specifications. ▪ Obtain input from experts regarding the content domains, performance categories and test specifications.

[3] The brief description provided draws extensively on the work of Hambleton & Zenisky (2003: 377-404). For a more comprehensive discussion, readers are referred to these authors.

Test Development	Research Activities
<u>Item writing and development of scoring rubrics:</u> A sufficient number of items need to be drafted for field testing; draft items must be edited and scoring rubrics need to be developed.	▪ Review various item types that could be used. ▪ Identify potential item banks.
<u>Assessment of content validity:</u> Identify a pool of content and measurement experts. The experts review the items to determine whether they match the content standards, their representativeness, their cultural appropriateness and freedom from potential bias, and their technical adequacy.	▪ Expert panels review each item to see if it meets the content standard and to classify it into a performance category. ▪ Expert panels review each item for appropriateness of language level and for potential gender and cultural bias.
<u>Revise test items:</u> Based on the input of the experts, revise the test items (or delete them) and write additional items, if necessary.	▪ Review and evaluate each revised item for content, linguistic, cultural and gender appropriateness.

2. Field Testing, Psychometric Evaluation and Standard Setting Phase

Test Development Activities	Research Activities
<u>Field test the experimental items:</u> Administer items to appropriately selected groups of test-takers. Conduct item analysis and perform item bias studies to identify differential item functioning (DIF).	▪ Item analysis ▪ DIF analysis
<u>Revise test items and establish item bank:</u> Using the results from the field testing, revise or delete items where necessary. A final item bank should then be established. Testlets should be identified in item bank.	▪ Review and evaluate each revised item for content, linguistic, cultural and gender appropriateness. ▪ Compile information on item characteristics for each item in item bank.

Test Development Activities	Research Activities
<u>Compile and administer a pilot test:</u> Decide on the number of items per content standard and the length of the test. Select test items and testlets from the item bank. Include anchor test items if the test is to be linked to a previous test or tests. Prepare the test booklet, practice examples, answer sheets, scoring keys, etc. Administer test to appropriate samples.	
<u>Explore psychometric properties:</u> The following needs to be established: ▮ Validity (content and criterion-referenced especially) ▮ Reliability (internal consistency) ▮ Construct equivalence for inter alia different language, cultural and gender groups.	▮ Evaluate the validity and reliability of the NBTs. ▮ Focus especially on the cross-cultural and cross-linguistic appropriateness and validity of the NBTs. ▮ Guidelines prepared by the International Test Commission (ITC), the American Psychological Association (APA), the European Federation of Psychological Associations (EFPA), and the Professional Board for Psychology will be used to guide and evaluate the research into the psychometric properties and quality of the NBTs.
<u>Finalise and verify performance standards (benchmarks):</u> Develop a process to determine the performance standards to separate test-takers into performance categories. Compile procedural, internal and external validity evidence to support the performance standards (Cizek, 2001). Specify factors that may affect the performance standards when they are applied to test-takers with special needs (i.e., alternative administration procedures to accommodate test-takers and the concomitant alternative test score interpretations).	▮ Evaluate and verify performance standards and benchmarks set against actual performance of learners in first-year and in subsequent years of study. ▮ Suggest adjustments to performance categories, item placement, and benchmarks on the basis of verification research. ▮ Enrich the descriptions of performance categories on the basis of verification data collected.

3. Finalisation of Test and Ongoing Evaluation Phase

Test Development Activities	Research Activities
Finalise the test administration procedures through pilot testing.	▮ Collect data on aspects of test administration procedure which are problematic and whether the language used in the instructions poses any difficulties.
Prepare a test manual for administrators as well as a manual containing technical and psychometric information.	▮ Ensure that the technical manual clearly documents the test development process and provides sufficient information on the psychometric properties of the test.
Ongoing collection of psychometric information and the equating of tests. If a different test is to be compiled each year, it is important that each new test is statistically linked or equated to tests administered previously so that scores are comparable across the tests. This will ensure that the previously established performance standards can be used with new tests and any growth or change can be identified. Equating usually involves using "anchor test items" and then "statistically equating" new tests to those given previously (Hambleton & Zenisky, 2003: 384). Anchor (common) items are items that were administered in previous tests and are included in the new test. Usually, anchor items are chosen to match the content of the tests being equated, and to be of comparable difficulty. If there are 10 to 15 anchor (common) test items and 1000 or more test-takers, this is sufficient to statistically equate two tests, although the larger the number of test-takers and anchor/common items, the better (Hambleton & Zenisky, 2003). As expressed by these authors, 'When tests are statistically equated, fairness can be achieved, the same performance standards can be used over time, and progress in achievement over time can be monitored' (2003: 384).	▮ Conduct reliability and validity studies on an ongoing basis. ▮ Statistically equate the tests used in any one intake-year and also from year to year. This will entail ensuring that anchor items are included in the tests to be equated and then performing the necessary statistical procedures to establish whether the tests are equivalent.

Managing the National Benchmark Tests Project (NBTP)

Three major tasks will constitute the NBT Project:

1. Test development;
2. Research; and
3. Project management.

The first two tasks were extensively discussed in the section above. Consequently, the only aspect that still needs elaboration is the way in which the NBT Project will be managed.

HESA's Executive Office has outsourced the management of the NBT Project to the Centre for Higher Education Development (CHED) at the University of Cape Town.

In the short- to medium-term the project will be managed by a Strategy Group made up of the following individuals:

- Professor Nan Yeld, NBT Project Director
- Professor Cheryl Foxcroft, Research and QA Coordinator
- Leaders of the test development teams – Drs Alan Cliff (verbal reasoning), Robert Prince (quantitative literacy) and Kwena Masha, in collaboration with Carol Bohlmann and Max Braun (cognitive academic mathematical proficiency).
- George van der Ross, Project Manager.

The leaders of the specialist task teams have recruited through a rigorous and transparent process test development experts to participate in test development. The process of test development and research will continue to involve both expert-driven small development and review teams and a larger reference group drawn from a range of institutional expertise (see Appendix 1).

The Strategy Group will include liaison with the HESA Executive Office and the Matriculation Board through the following individuals:

- Hanlie Griesel, with regard to the framework and approach of the NBTP, its accountability to HESA structures and the synergies which need to be developed with HESA's enrolment services (see diagram in Section 1, page 2); and
- Cobus Lötter, in terms of budgetary provisions and fund-raising activity.

In terms of sector-level governance, the NBTP will be accountable to the HESA Enrolment Steering Committee responsible for the overall strategic direction and alignment of four distinct yet interrelated enrolment services, i.e.:

- An information service – the current National Information Service for Higher Education (NiSHE) which may in future extend to include a central applications service;
- An minimum admissions regulation service – the current Matriculation Board and future Minimum Admissions Service; and
- HESA's project on monitoring systems flow focused on enrolment, retention and graduation trends.

It is clearly important that the NBTP is guided by a governance model that is in line with the vision and functions of a coherent HE enrolment system, as well as the strategic plan of HESA. In addition, the outcomes of the NBTP will be of direct interest to the newly established Admissions Committee of HESA, responsible for regulating minimum admissions requirements and preparing the higher education sector for system readiness in 2008 when the current Senior Certificate is replaced by the new National Senior Certificate.

Concluding comment

The task of developing national benchmark tests is by no means simple and it will take a while for the tests and benchmarks (standards) to be developed. However, there is a large pool of international and national knowledge and literature that can be drawn on in terms of the steps that need to be followed when developing criterion-referenced national tests, verifying their psychometric properties, and setting minimum performance standards (benchmarks). Furthermore, a pool of test development experts has emerged across HE institutions in South Africa over the last decade or more. Consequently, there is every reason to believe that the complex task of developing high quality national benchmark tests by 2008 can realistically be achieved.

Section 3 focuses on the test domains and constructs that the NBTs will tap. These test domains and constructs will guide item development and the delineation of performance standards.

3

TEST DOMAINS AND CONSTRUCTS

Overview

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The testing of academic literacy (verbal reasoning and quantitative reasoning or numeracy) for admissions and placement purposes has a long history, in South Africa as well as internationally. The critical thinking skills in these domains are widely believed to be central to academic success in higher education study, irrespective of area of study. Similarly, ability and knowledge in mathematics are generally held to be essential for satisfactory progress in areas of study requiring a sound mathematical and quantitative foundation. The domains are fully explored in Section 3 below.

Examples of international testing initiatives widely used for benchmarking of school-leaving examinations, or for direct admission to institutions here and elsewhere in the world, include:

- the SAT 1 Verbal Reasoning test developed by the Educational Testing Service (ETS) in the United States, which incorporates critical reading, mathematics and writing;
- the Queensland Core Skills Test scheme in Australia;
- the ETS Test of English as a Foreign Language (TOEFL);
- the University of Cambridge Local Examinations Syndicate's International English Language Testing Service (IELTS); and
- the Test in English for Educational Purposes (TEEP) in the United Kingdom.

In South Africa, two system-level projects have developed and implemented testing schemes, based on academic literacy, numeracy and (in some cases) scientific reasoning[4]:

- The Alternative Admissions Research Project (AARP) was established in the late 1980s at the University of Cape Town.

AARP's goals are, broadly speaking, to provide a student selection and placement testing service, and to contribute to the development of national policies relating to admissions. From its small beginnings, AARP has grown dramatically, both in numbers of students writing the tests, numbers of institutions participating, and their reasons for doing so. Testing is undertaken for a number of institutions and, in recent years, its activities have included the development of the Health Sciences consortium, which is responsible for a national entrance examination (in language, mathematics and scientific reasoning) written by almost all applicants wishing to enter the Health Sciences profession.

- The second major local testing initiative, the Assessment Project (TELP II), was initiated in November 1998.

The brief from the Tertiary Education Linkages Project (TELP) was to develop three diagnostic tests, in the areas of English Language (academic literacy), Mathematics and Science, which could be used to identify students at risk in the Historically Disadvantaged Institutions (HDIs) and provide a basis for the development of appropriate courses and curricula. In the 1990s, a further, complementary aim and use of the tests arose: to identify talented students whose Senior Certificate results did not make them eligible for selection to higher education studies. Although funding for the TELP project officially came to an end in 2002, the project has since continued on limited funding and pro-bono commitment of time and resources from AARP staff, working with staff at the formerly TELP institutions, along with commitment from the institutions themselves to print, administer and mark the tests. It is now known as the Standardised Assessment Tests for Access and Placement (SATAP) Project.

Together, the two projects process about 78,196 scripts annually, which represent approximately 26,734 writers.

The deliberate intention of the NBTP is to build on the expertise developed in these two national system-level testing initiatives – as well as on expertise developed in institution-specific assessment practices – in the development entry-level benchmarks in similar domains; i.e. academic and quantitative literacy and mathematics proficiency.

In conclusion, it is important briefly to comment on the language of the tests under development. The decision has been reached that in the development phase of the NBTP, the language of the tests will initially be English. Although less than 10% of the South African population speaks English as a first language, it is the medium of instruction in the majority of the country's secondary schools and higher education institutions. This depiction of the status quo should not, however, be taken to imply uncritical support for the hegemony of English in formal education in South Africa. Neither is there any reason why the tests should not be translated into Afrikaans where this is an institution's medium of instruction or, for that matter, into any one of the other official South African languages that may, in future, become the medium of instruction at a particular institution.

[4] In addition, several regional and institution-specific initiatives were developed that, in various forms, created access opportunities for a wider group of students than could be identified through total reliance on the "matric" examination. Prominent amongst these were the Teach-Test-Teach (TTT) programme at the University of Natal and the University Foundation Year (UNIFY) project at the then University of the North. Expertise from these and other projects is contributing crucially to the NBTP.

Domain 1–

Academic Literacy
Alan Cliff and Nan Yeld

Quantitative Literacy
Vera Frith and Robert Prince
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Academic Literacy

A national benchmark test in academic literacy needs to address the following central question:

> What are the core academic literacy competencies that an entry-level student should demonstrate that will be sufficient indication that s/he will be able to cope with the typical demands of higher education in the medium-of-instruction of an institution, in a context of appropriate teaching, learning and curriculum support?

This question foregrounds certain key elements that should be considered in developing an academic literacy benchmark test:

- It suggests that there should be an identification of what exactly is meant by "core" academic literacy competencies, i.e. what are the key language and thinking competencies and approaches that should be assessed? This question is explored further on in this section.
- There is an important focus on "entry-level" competencies, i.e. there should be careful debate about how entry-level competencies might differ from exit-level (or graduate-level) outcomes and how it is the former which should be assessed in a benchmark test. It should also be noted that the current prevalent view that a large proportion of South Africa's school leavers do not in fact possess the required competencies should not be allowed to influence the benchmark levels: rather, until schooling improves, the onus needs to be on higher education to provide educational support so that students develop to meet these levels.
- The question of what exactly constitutes "sufficient" indication of academic literacy competence also needs debate. In the context of higher education in South Africa, "sufficient" indication of academic literacy may depend at least upon 1) the level of qualification (e.g. certificate, diploma or degree) for which the student is studying; and 2) the extent of curriculum provision and support (e.g. foundation, mainstream) provided for that programme.

The medium-of-instruction issue is also of key importance: an academic literacy test should aim to assess a student's competence in dealing with the language demands of medium-of-instruction, not first language per se– insofar as medium of instruction and first language are separable.

What is academic literacy?

The view of academic literacy put forward here represents a focus on students' capacities to engage successfully with the demands of academic study in the medium of instruction of the particular study environment. In this sense, success is constituted of the interplay between the language (medium-of-instruction) and the academic demands (typical tasks required in higher education) placed upon students. Perhaps it is successful negotiation of this interplay that might reasonably be regarded as the notion of "academic literacy". A successful student in this sense, then, is one who is able to negotiate the demands of academic study in a higher education context, in the medium-of-instruction of that context, and eventually graduate with a meaningful qualification. "Success" is here constituted as the student having perceived the nature of the language and thinking demands placed upon him or her and having made appropriate responses to those demands.

So, what are the language and thinking demands of the academic context that a student is expected to negotiate, and negotiate successfully – i.e. what is the target language use domain?

Bachman and Palmer (1996: 44) define this domain as "a set of specific language use tasks that the test taker is likely to encounter outside of the test itself and about which we want our inferences about language ability to generalise". Clearly, these tasks pose demands that are complex and multi-dimensional, and difficult to assess.

Bachman and Palmer's research, which occupies a central place in the field of language assessment, highlights various language and thinking approaches associated with successful higher education study engagement. Of particular interest here is their focus on the knowledge and understanding of the organisational and functional aspects of the language of instruction. Successful students, by implication, are those who are able to negotiate the grammatical and textual structure of the language of instruction and to understand its functional and socio-linguistic bases. In a higher education context, what this translates to is that successful students are able to:

1. negotiate meaning at word, sentence, paragraph and whole-text level;
2. understand discourse and argument structure and the text "signals" that underlie this structure;
3. extrapolate and draw inferences beyond what has been stated in text;
4. separate essential from non-essential and super-ordinate from sub-ordinate information;
5. understand and interpret visually encoded information, such as graphs, diagrams and flow-charts;
6. understand and manipulate numerical information;
7. understand the importance and authority of "own voice";
8. understand and encode the metaphorical, non-literal and idiomatic bases of language; and
9. negotiate and analyse text genre.

Cummins (e.g. 2000, 1984, 1980) proposes two different conceptions of language proficiency that are useful in this context. He was concerned to understand why students who appear fluent in a language frequently experience difficulties when that language is used as the medium of instruction. That is, he was interested in the abilities lying behind the successful deployment of language in academic settings and whether, and in what ways, these were different from the abilities underlying the use of language in non-school settings. It was in this context that he argued for language proficiency to be defined in a way that could be related to academic performance. In suggesting that academic success requires using and understanding language in context-reduced situations, he drew a distinction between the use of language in context-reduced as opposed to context-embedded situations.

Cummins's argument was that tests arising from communicative competence theories of language use would tend to tap only one dimension of the language abilities required to function effectively in formal schooling. He called this dimension basic interpersonal communicative skills (BICS), and contrasted it with that of cognitive academic language proficiency (CALP) which was intended to capture the kinds of language ability needed to function effectively in schooling. As Cummins and Swain (1986: 151) point out, it is "... necessary to distinguish between the processing of language in informal everyday situations and the language processing required in most academic situations".

The situations being referred to here are typically decontextualised and found in formal schooling contexts, and some of the processing demands arise from the absence, in many academic situations, of the normal supports found in conversation (e.g. nods, interpolations, gestures), and the need to function as both audience and speaker (Bereiter & Scardamalia, 1982). More specifically, decontextualised language use refers to "... language used in ways that eschew reliance on shared social and physical context in favour of reliance on a context created through the language itself" (Snow, Cancino, De Temple & Schley, 1991). It can be defined as requiring:

- "... the linguistic skills prerequisite to giving, deleting, and establishing relationships among the right bits of information" (Snow 1987: 6), and control of "... the complex syntax necessary to integrate and explicate relations among bits of information, and maintaining cohesion and coherence" (op cit: 7).

- proficiency in processing text irrespective of mode (i.e. spoken or written) or medium (e.g. books, journals, visual material, electronic forms) where meaning is supported by linguistic rather than paralinguistic cues (Tannen 1985; Cummins 1980, 1984; Wells 1981).

- communication, irrespective of mode or medium, where the emphasis is on the message rather than the act of communication (Tannen 1985; Wells 1981; Arena 1975).

The first of Cummins's two conceptions of language proficiency relates to the concept of communicative competence, which is firmly embedded in linguistic and sociolinguistic theory. In this view, it is the act of communication that is prioritised, rather than the message. The communicative competence movement, which arose in reaction to a view of language as the sum of numerous discrete elements, understandably fore-grounded interaction, context, and authenticity in human communication. The role of world knowledge, and other relatively non-linguistic cognitive factors was not, however, adequately addressed. It is this lack that the second of Cummins's proposals attempts to address and, in doing so, it draws on psychological theory for its insights, rather than linguistics or sociolinguistics. It is based on

> "...an analysis of the requirements of language tasks with respect to two dimensions: the degree to which the language task is supported by non-linguistic contextual cues, and the degree of cognitive effort involved in task performance " (Cummins & Swain 1986: 205).

Language proficiency is thus conceptualised along two continua, 1) degree of contextual support; and 2) cognitive complexity. The use of two continua rather than one represents an attempt to avoid the oversimplifying effects of dichotomising constructs into two categories, as well as more adequately representing the two kinds of task demand characteristics identified by Cummins. It also explicitly links language proficiency and cognitive theories of knowing and learning.

The first continuum relates to the degree of contextual support available for a task, and the second to the degree of cognitive effort required by tasks. As with the contextual support continuum, a particular task or situation does not have a predetermined place on the continuum. The degree of effort (i.e. how difficult the task is for the individual) is more closely related, for an individual, to the individual's degree of mastery of the linguistic tools necessary for the task, than to some inherent quality of the task itself. These linguistic tools include, following the Bachman (1990) and Bachman and Palmer (1996) models outlined below:

a. topical knowledge (e.g. the individual's knowledge, broadly defined, about the topic at hand);
b. language knowledge (which includes the following categories – grammatical, textual, functional and sociolinguistic). Interacting with and directing these components are
c. strategic competence, or metacognitive strategy use (the effectiveness of the individual at planning, monitoring, and modifying the language required and used by the test task); and
d. the individual's affective schemata, which affect the way in which tasks are approached and undertaken.

Returning to Cummins's model: as the degree of mastery of the linguistic tools necessary for the task increases, the degree of cognitive effort required for the task decreases, and the same task assumes a different place on the continuum (it moves up towards the undemanding end). This, of course, begs the question of how mastery of the linguistic tools can be acquired: in this respect Cummins (2000: 71) suggests that "... language and content will be acquired most successfully when students are challenged cognitively but provided with the contextual and linguistic support or scaffolds required for successful task completion".

It is with this second conception of language proficiency that connections with academic performance are often made. In particular, the linking of linguistic tools to task performance rather than to the more general notion of communicative competence makes a good deal of sense in contexts of widespread educational disadvantage. Poor educational systems do not, in general, provide appropriate opportunities for the development of task-related academic language skills. In this connection, the situation of educationally disadvantaged South African students is particularly difficult, and it is important to note that Cummins's framework, developed as it was in a very different context (Canadian secondary schooling) assumes that learners will already have developed "task-relevant" linguistic skills in their first language. Nevertheless, the two-continua model provides a "useful conceptual heuristic" (Yeld 2001: 161) for test development, reminding test developers about the numerous variables that can impact on performance.

An important additional set of insights comes from New Literacy Studies (NLS) theorists and practitioners who have as a fundamental tenet that literacy is a set of practices located (or situated) in specific contexts – indeed, more recent NLS thinking holds that "... meaning and context are mutually constitutive of each other" (Gee 2000: 190). However, in a study exploring the implications of the NLS approach for large-scale entrance-level assessment, it is argued that it is the extent to which a candidate can produce a performance that is interpretable from within a very specific context – that of higher education – that will count (Yeld 2001: 132).

The language proficiency work above is supplemented by understandings from the work of the Student Learning Research framework (see, for example, Marton & Säljö's, 1976a & b; 1984; Entwistle & Ramsden, 1983; Marton, Dall'Alba & Beaty, 1993). Studies based on the Student Learning Research framework have consistently sought to address the challenge presented by assessing students' contextualised approaches to language and learning. It is not enough that language and learning approaches influence meaning-making; it is how these elements interact with each other in a specific and authentic higher education context that constitutes academic literacy or the absence thereof. Writers within the Student Learning Research framework point to successful higher education study being associated with students who are able to:

a. separate the point of an argument from its supporting detail;
b. interact vigorously and critically with ideas in text and elsewhere;
c. produce well-reasoned arguments supported by appropriate evidence;
d. perceive the structure and coherence of text, as well as the organisation of ideas that contributes to that structure;
e. understand that learning involves negotiating meaning, applying insights in different contexts, developing a view of one's own, and "seeing" the world differently as a consequence of these.

There would appear to be parallels in the views of the researchers on language, learning and thinking mentioned in the foregoing, and the point of central interest to this research rationale is that the "academically literate" student is one who has managed to negotiate at least the abovementioned demands in a context of appropriate and adequate support for learning development.

Operationalising academic literacy

An assessment of the academic literacy levels of a student on entry to higher education should be developed around a central construct, which embodies the following principles in its design:

- Language should be seen as the vehicle, not the target. This principle relates to earlier discussion of academic literacy as a capacity to cope with the higher education reading, writing and thinking demands in the medium-of-instruction;
- Assessment should be generic, i.e. any assessment should be based on the typical academic literacy requirements of any or all disciplines;
- Any assessment should be developed in such a way that test-takers have the opportunity to demonstrate competence in a "real" context that bears relation in its complexity to the context in which they will study;
- Assessment should downplay the role of exposure to prior content knowledge and be aimed at assessing test takers' ability to grapple with academic literacy processes (as delineated in Figure 1 below);
- The construct should be based on inputs from inter-disciplinary panels of expertise to ensure that it has high face validity and that what is assessed bears direct relation to what is likely to be required (in a generic sense) of test takers in any higher education context.

Staff of the Alternative Admissions Research Project, working with colleagues from several higher education institutions (see, for example, Cliff, Yeld & Hanslo, under review), have sought to operationalise the above notions of academic literacy in terms of a framework of language knowledge specifications, i.e. what students would be required to demonstrate as a benchmark of performance for the domain of academic literacy. The following table shows the inter-relationship between the language proficiency required of an academically literate student and the operationalising of this framework in terms of a set of specifications on a benchmark test: it also illustrates how it is possible – even desirable – to attempt some form of description of language and thinking competencies.

Table 1: Language Knowledge Specifications

Language Knowledge (Bachman & Palmer, 1996)		Language Knowledge Specifications used in PTEEP test construction	Description of Skill Area
ORGANISATIONAL KNOWLEDGE	Grammatical Vocabulary Morphology Syntax	Vocabulary: "unknown" and "known" vocabulary	Students' established vocabulary Students' abilities to derive/work out word meanings from their context, plus "known" vocabulary
		Spelling as it affects meaning	
		Syntax	Students' abilities to recognise and manipulate the syntactical basis of the language
	Textual Cohesion Rhetorical organisation	Understanding relations between parts of text	Students' capacities to "see" the structure and organisation of discourse and argument, by such means as: ▪ using devices of cohesion such as pronoun reference, particularly demonstratives, referring to statements/propositions or "entities", ▪ paying attention – within and between paragraphs in text – to transitions in argument; superordinate and subordinate ideas; introductions and conclusions; logical development of ideas;
		Skimming and scanning	Students' abilities to use macro features of text such as headings, illustrations) to get gist of passage, or to locate particular pieces of information
		Inference, extrapolation and application	Students' capacities to draw conclusions and apply insights, either on the basis of what is stated in texts or is implied but not explicitly stated in these texts.

PRAGMATIC KNOWLEDGE	<u>Functional knowledge</u> Ideational Manipulative Heuristic Imaginative	Separating the essential from the non–essential	Students' capacities to "see" main ideas and supporting detail; statements and examples; facts and opinions; propositions and their arguments; being able to classify, categorise and 'label'
		Detailed reading for meaning	Students abilities to "get at" meaning,at sentence level and at discourse level
		Understanding the communicative function of sentences with or without explicit indicators	Students' abilities to "see" how parts of sentences / discourse define other parts; or are examples of ideas; or are supports for arguments; or attempts to persuade; or to define.
		Understanding the importance of "own voice" (including "ownership" of ideas) and/or creativity of thought and expression	Students' abilities to use "own voice" appropriately and effectively, and to acknowledge sources of ideas or information (stage specific)
		Understanding visually encoded forms of information representation	Students' abilities to understand and use graphs, tables, diagrams, pictures, maps, flow-charts
	<u>Sociolinguistic knowledge</u> (sensitivity to dialect, language variety; register; naturalness criteria)	Understanding basic numerical concepts expressed in text and undertake simple numerical manipulations	Students' abilities to make numerical estimations; comparisons; calculate percentages and fractions; make chronological references and sequence events / processes; perform basic computations
		Understanding metaphorical expression	Students' abilities to understand and work with metaphor in language. This includes their capacity to perceive language connotation, word play, ambiguity, idiomatic expressions, and so on. Familiarity with cultural references and figures of speech
		Understanding text genre	Students' abilities to perceive "audience" in text and purpose in writing, including an ability to understand text register (formality / informality) and tone (didactic / informative / persuasive / etc.),

It goes almost without saying that there is likely to be some degree of overlap between the specification of numerical competence described in Figure 1 and at least one of the foci of a numeracy benchmark test described by Frith and Prince (see below). Suffice it to say here that the specification of numeracy in a test of academic literacy relates to students being able to demonstrate a basic understanding of information conveyed by numbers as they might encounter this in texts that range across disciplines, i.e. from the sciences, to commerce, to the humanities and the social sciences.

One further important challenge to the assessment of academic literacy benchmark performance is to determine different levels of benchmark performance across particular domains of the test. It is not sufficient for a benchmark test to determine the construct of academic literacy and to operationalise this construct: the test should also be able to assess different benchmark levels within domains. For example, if a benchmark test is to assess students' grasp of information presented visually, then it should also have specified the level of proficiency required for a student to access diploma study or degree study.

In an early attempt to explore learners' conceptions of learning from a phenomenographic perspective, Säljö's (1979) study reported five qualitatively distinctive categorisations of learning conception. Based on learners' self-reports, these categorisations essentially suggested two contrasting ways in which the process of learning could be conceived: as a process of collecting and assimilating information or as a process of transforming that information. The model seemed to depict these processes in hierarchical terms. Processes of transforming knowledge, applying it in different contexts, interpretation, and making personal meaning were portrayed as being hierarchically superior to (or more inclusive than) processes of collecting information, remembering it, and being able to reproduce it mechanically for assessment purposes. The former processes were viewed as superior to the latter in the sense that they appeared to involve some form of reworking, personal understanding and integration of knowledge, whereas the latter involved rote engagement without any attempt at reinterpretation or personal sense-making. In the context of the present discussion of benchmarking, then, the reproductive and transformative dimensions referred to here can be seen as forms of benchmarking student responses. For candidates whose successful performance falls overwhelmingly within the reproductive dimension rather than the transformative, it can be concluded that they are highly likely to have been unable to transform what they have learned and may arguably not yet be sufficiently academically literate. The challenge in benchmarking performance, though, lies in being able to assess the extent to which the transformative dimension is sufficiently in evidence to suggest that a student is likely to cope with the demands of higher education study at a particular level.

The results of Säljö's original study have been replicated and extended by other research studies. These include findings of associations between these conceptions and learning outcome (Van Rossum & Schenk, 1984) and associations between conceptions and learners' perceptions of other important academic context variables, such as teaching and assessment. A longitudinal study of learning conception by Marton, Dall'Alba & Beaty (1993) reported a sixth qualitatively distinct dimension of learning conception: learning as changing a person.

One of the difficulties for assessment of models that conceive of learning processes as hierarchically organised, however, is that they ignore the fact that it is possible to assess processes in easy as well as difficult ways – so a "hierarchically superior" process might in fact be assessed in such a way (for example, by using a very simple context) as to be easier than the assessment of a supposedly inferior one. As Mullis et al (2003: 25) argue,

> "In general, the cognitive complexity of tasks increases from one broad cognitive domain to the next. [....]. Nevertheless, cognitive complexity should not be confused with item difficulty. For nearly all the cognitive skills listed, it is possible to create relatively easy items as well as very challenging items. In developing items aligned with the skills, it is expected that a range of item difficulties will be obtained for each one, and that item difficulty should not affect the designation of the cognitive skill."

Concluding Comment

There are many assessment frameworks currently in use. Well-known examples are those used by the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS) Assessment Frameworks. A modified version of these is proposed by the DoE (see the Subject Assessment Guidelines for Mathematics Literacy, for example[5]). An interesting recent development is the project undertaken from 1995-2000 in the United States, to revise the most famous of all taxonomies: Bloom's 1949 taxonomy of educational objectives (Bloom et al, 1949). The revised taxonomy derives partly from the original structure of educational objectives, but incorporates advances in cognitive psychology and takes into account the many other initiatives since 1949. It offers a potentially useful set of six categories which make up the "cognitive process dimension", and separates this from the "knowledge dimension" which, in turn, is subdivided into four categories (see Anderson, 2005 for a concise exposition of the revised taxonomy). Its interest to the NBTP lies partly in the widespread recognition given to the original Bloom's taxonomy, which means that it is instantly recognisable by educators in all walks of life, and partly because its use as an assessment framework is presently being investigated by various South African initiatives.

At this stage no final decision has been made about which approach to use, as the test development team is currently assessing the appropriateness and feasibility of several approaches.

[5] The document is available on the following website:
http://www.education.gov.za/mainDocument.asp?src=docu&xsrc=poli.

Quantitative Literacy

A national benchmark test in Quantitative Literacy needs to address the same central question as framed in the previous section on Academic Literacy and should foreground the same key elements to consider, such as:

- What is meant by "core" quantitative literacy competencies in higher education?
- What is meant by "sufficient" quantitative literacy competencies for different levels of qualification, disciplines and curricula in higher education?

What is quantitative literacy at tertiary level?

For a working definition of the domain, Quantitative Literacy, and its assessment we draw on, amongst other sources, the work of Street (1995), Baynham and Baker (2002), Chapman and Lee (1990), Chapman (1998), Steen (2001), Jablonka (2003), the Adult Literacy and Lifeskills (ALL) Survey, the Programme for International Student Assessment (PISA), the Third International Mathematics and Science Study (Mullis, 2003) Assessment Frameworks and the experience of the Quantitative Literacy Test project of the Numeracy Centre at the University of Cape Town (see Frith, Bowie, Gray & Prince, 2003; Frith, Jaftha & Prince, 2004a). We present a definition of quantitative literacy (and reasoning) that can be used, amongst other purposes, to operationalise the development of a Quantitative Literacy Benchmark Test.

There is an ongoing debate about the meaning of the term "Quantitative Literacy" (also known as "numeracy" or "mathematical literacy" in different countries and/or contexts) and its relationship to "literacy" and to "mathematics". This debate is exemplified by the various articles in *Mathematics and Democracy: The Case for Quantitative Literacy* (Steen, 2001), in which the preface states that the book "does not seek to end debate about the meaning of numeracy. On the contrary, it aspires instead to be a starting point for a much needed wider conversation" (Orrill, 2001: xvii).

We contend that the concept of "practice" (Lave & Wenger, 1991) is a useful and generative way of thinking about quantitative literacy (Prince & Archer, 2005; Archer, Frith & Prince, 2002). Quantitative literacy cannot be seen as a set of identifiable mathematical skills that can be taught and learned without reference to the social contexts where they might be applied. Baynham and Baker (2002: 2) stress that the term practice is used to incorporate "both what people do and the ideas, attitudes, ideologies and values that inform what they do." They attribute the introduction of the term "practice" in this way for describing quantitative literacy to Street (1984). Baker, Clay and Fox (1996: 3) refer to "the collection of numeracy practices that people engage in – that is the contexts, power relations and activities – when they are doing mathematics". Jablonka (2003: 78) also argues that the promotion of any definition of mathematical literacy will implicitly or explicitly promote a particular social practice.

Chapman and Lee (1990: 277) in thinking about numeracy and learning at tertiary level, attempt to "situate numeracy within a larger reconceptualised notion of literacy". They argue that it is not possible to draw an artificial separation between the notions of quantitative literacy and literacy, but rather that quantitative literacy involves many competencies: "reading, writing and mathematics are inextricably interrelated in the ways in which they are used in communication and hence in learning." Chapman (1998) develops a framework for what she calls "academic numeracy" as a means for describing the numeracy demands of academic texts and tasks.

We take the view that quantitative literacy, can be described in terms of 1) the contexts that require the activation of quantitative literacy practice; 2) the mathematical and statistical content that is required when quantitative literacy is practiced; and 3) the underlying reasoning and behaviours that are called upon to respond to a situation requiring the activation of quantitative literacy practice.

Contexts

The various positions presented in Steen (2001) reinforce the idea that quantitative literacy practice, as opposed to mathematics, is always embedded within a context. Yet, until now, the dominant pedagogical practice of teaching mathematical literacy in the restricted context of the formal mathematics classroom is at odds with this idea. Usiskin (2001) warns against the use of contrived "real-life" examples masquerading as "reality" in the mathematics classroom. Teaching quantitative literacy requires the use of authentic contexts, which need to be understood as clearly as the mathematics that is being applied. Hughes-Hallett (2001: 94) summarises the difference between quantitative literacy and mathematics as follows:

> ...mathematics focuses on climbing the ladder of abstraction, while quantitative literacy clings to context. Mathematics asks students to rise above context, while quantitative literacy asks students to stay in context. Mathematics is about general principles that can be applied in a range of contexts; quantitative literacy is about seeing every context through a quantitative lens.

In terms of developing a benchmark test, the challenge is to find contexts that are sufficiently relevant that they motivate test-takers to truly display their potential for quantitatively literate practice.

Content

Clearly mathematical and statistical content knowledge is essential for quantitatively literate practice, although there will be debate about the exact nature of appropriate content knowledge for different contexts and/or academic disciplines. The point is made by Steen (2001) and Hughes-Hallett (2001) that statistics and data handling (rather than traditional school mathematics topics) play a dominant role in quantitative literacy, and this is certainly true of the quantitative literacy required for many academic disciplines. To be quantitatively literate at tertiary level, a student will need a great deal more than just basic arithmetic and mathematical skills.

Reasoning and behaviours

According to Jablonka (2003: 78), "Any attempt at defining 'Mathematical Literacy' faces the problem that it cannot be conceptualised exclusively in terms of mathematical knowledge, because it is about an individual's capacity to use and apply this knowledge. Thus it has to be conceived of in functional terms as applicable to the situations in which the knowledge is to be used." This emphasis on the use and application of knowledge implicitly assumes the importance of the associated quantitative thinking and reasoning. In the literature, there is no clear definition or characterisation of these "mathematical actions" which include such activities as drawing connections, visualising, questioning, representing, concluding and communicating (Boaler, 2001). Clearly it is imperative that some characterisation of these critical competencies must be part of a test construct for quantitative literacy.

Being numerate requires the ability to express quantitative information coherently in a verbal and visual form. Kemp (1995) argues that mathematical literacy includes the ability to communicate clearly and fluently and to think critically and logically. In dealing with quantitative or mathematical ideas in context, students should be able to interpret information presented either verbally, graphically, in tabular or symbolic form, and be able to make transformations between these different representations. The transformation of quantitative ideas into verbal messages is the area where a student's ability to write coherently about quantitative ideas will be exercised. Mathematical literacy also requires the ability to choose the appropriate form for the expression of a quantitative idea, and to produce a text that expresses that idea. Thus the practice of mathematical literacy must include the ability to put together a document for a particular purpose in a particular context.

Definition

We adopt the following definition of quantitative literacy, in which all three approaches to the description (contexts, content and reasoning) are embedded:

> Quantitative literacy is the ability to manage situations or solve problems in practice, and involves responding to quantitative (mathematical and statistical) information that may be presented verbally, graphically, in tabular or symbolic form; it requires the activation of a range of enabling knowledge, behaviours and processes and it can be observed when it is expressed in the form of a communication, in written, oral or visual mode.

This definition has been informed by the discussions and definitions implicit in the frameworks used by NAEP (National Assessment Governing Board, 2004), TIMMS (Mullis et al, 2003), PISA (Programme for International Student Assessment, 2003) and ALL (2002) studies. The relevant components of these frameworks will be further discussed in our elaboration of the definition in Appendix 1.

Table 2 below provides an expanded representation of the elements that make up this definition, which is further elaborated in detail in Appendix 2 (pages 47-54). In particular, the following elements are explicated:

- Real contexts
- Responding
- Quantitative information
- Representation of quantitative ideas
- Activation of enabling knowledge, behaviours and processes
- Expressions of quantitatively literate behaviour

Table 2: An expanded representation of the definition of quantitative literacy

Quantitative literacy is the ability to:

- manage a situation or solve a problem in a real context
  - Education (tertiary) – Health, Law, Social Science, Commerce etc.
  - Professions – Health, Law, Social Science, Commerce etc.
  - Personal Finance
  - Personal Health
  - Management
  - Workplace
  - Citizenship
  - Culture
- by responding
  - Comprehending: identifying or locating
  - Acting upon
  - Interpreting
  - Communicating
- to information (about mathematical and statistical ideas)
  - Quantity and number
  - Shape, dimension and space
  - Relationships, pattern, permutation
  - Change and rates
  - Data representation and analysis
  - Chance and uncertainty

- that is represented in a range of ways
  - Numbers and symbols
  - Words (text)
  - Objects and pictures
  - Diagrams and maps
  - Charts
  - Tables
  - Graphs
  - Formulae
- and requires activation of a range of enabling knowledge, behaviours and processes
  - Quantitative (mathematical and statistical) knowledge
  - Mathematical and statistical techniques and "skills"
  - Quantitative reasoning
  - Literacy skills [language, visual]
  - Use of computational technology
  - Beliefs and attitudes
- it can be observed when it is expressed in the form of a "text"
  - Written
  - Oral
  - Visual [includes concrete objects]

Operationalisation of the definition for test development and analysis

Table 3 below summarises the operationalisation of the understanding of quantitative literacy for the purpose of test development and analysis. Criteria (or competence areas) selected to be assessed in a Quantitative Literacy benchmark test will depend on the choices made about the format, complexity level and test length. The Quantitative Literacy benchmark test may very well encompass specifications that overlap with other domains (Academic Literacy and Cognitive Academic Mathematical Proficiency). Items within the test may also simultaneously assess different competence areas (described in Table 3) within the Quantitative Literacy domain.

The competence areas defined in this table will allow the test itself, student results and cohort results to be analysed using clustering of items and criteria. For example, the test can be analysed from the point of view of which competencies (such as reasoning) are required, or which quantitative content areas are addressed (such as relationships or algebra).

In the section on Academic Literacy, the concluding discussion about classifying items in terms of cognitive complexity applies equally to the consideration of describing the complexity of test items in the Quantitative Literacy domain.

Table 3: Competencies Specification for a Quantitative Literacy Test

	Competence area	Description/specifications
Comprehending: identifying or locating	Vocabulary	The ability to understand the meanings of commonly encountered "quantitative" terms and phrases (such as percentage increase, rate, approximately, representative sample, compound interest, average, order, rank, category, expression, equation), and the mathematical and statistical concepts (including basic descriptive statistics) that these terms and phrases refer to.
	Representations of numbers and operations	The ability to understand the conventions for the representation of numbers (whole numbers, fractions, decimals, percentages, ratios, scientific notation), measurements, variables and simple operations (+, -, ×, ÷, positive exponentiation, square roots) on them.
	Conventions for visual representations	The ability to understand the conventions for the representation of data in tables (several rows and columns and with data of different types combined), charts (pie, bar, compound bar, stacked bar, "broken" line, scatter plots), graphs and diagrams (such as tree diagrams, scale and perspective drawings, and other visual representations of spatial entities)
Acting, interpreting, communicating	Using representations of data	The ability to derive and use information from representations of contextualised data and to interpret the meaning of this information.
	Computing	The ability to perform simple calculations as required by problems and to interpret the results of the calculations in the original context.
	Conjecturing	The ability to formulate appropriate questions and conjectures, in order to make sense of quantitative information and to recognise the tentativeness of conjectures based on insufficient evidence.
	Interpreting	The ability to interpret quantitative information (in terms of the context in which it is embedded) and to translate between different representations of the same data. This interpretation includes synthesising information from more than one source and identifying relationships (patterns) in data.

Acting, interpreting, communicating	Reasoning	The ability to identify whether a claim is supported by the available evidence, to formulate conclusions that can be made given specific evidence or to identify the evidence necessary to support a claim.
	Representing quantitative information	The ability to represent quantitative information verbally, graphically, diagrammatically and in tabular form.
	Describing quantitative relationships	The ability to describe patterns, comparisons between quantities, trends and relationships and to explain reasoning (linking evidence and claims)
Mathematical and statistical ideas	Quantity, number and operations.	▮ The ability to order quantities, calculate and estimate the answers to computations required by a context, using numbers (whole numbers, fractions, decimals, percentages, ratios, scientific notation) and simple operations (+, -, ×, ÷, positive exponentiation) on them. ▮ The ability to express the same decimal number in alternative ways (such as by converting a fraction to a percentage, a common fraction to a decimal fraction and so on). ▮ The ability to interpret the words and phrases used to describe ratios (relative differences) between quantities within a context, to convert such phrases to numerical representations, to perform calculations with them and to interpret the result in the original context. The ability to work similarly with ratios between quantities represented in tables and charts, and in scale diagrams.
	Shape, dimension and space.	▮ The ability to understand the conventions for the measurement and description (representation) of 2- and 3-dimensional objects, angles and direction, ▮ The ability to perform simple calculations involving areas, perimeters and volumes of simple shapes such as rectangles and cuboids.
	Relationships, pattern, permutation	▮ The ability to recognise, interpret and represent relationships and patterns in a variety of ways (graphs, tables, words and symbols) ▮ The ability to manipulate simple algebraic expressions using simple arithmetic operations.

Mathematical and statistical ideas	Change and rates	▪ The ability to distinguish between changes (or differences in magnitudes) expressed in absolute terms and those expressed in relative terms (for example as percentage change). ▪ The ability to quantify and reason about changes or differences. ▪ The ability to calculate average rates of change and to recognise that the steepness of a graph represents the rate of change of the dependent variable with respect to the independent variable. ▪ The ability to interpret curvature of graphs in terms of changes in rate.
	Data representation and analysis	▪ The ability to derive and use information from representations of contextualised data in tables (several rows and columns and with data of different types combined), charts (pie, bar, compound bar, stacked bar, "broken" line, scatter plots) graphs and diagrams (such as tree diagrams) and to interpret the meaning of this information. ▪ The ability to represent data in simple tables and charts, such as bar or line charts.
	Chance and uncertainty	▪ The ability to appreciate that many phenomena are uncertain and to quantify the chance of uncertain events using empirically derived data. This includes understanding the idea of taking a random sample. ▪ The ability to represent a probability as a number between 0 and 1, with 0 representing impossibility and 1 representing certainty.

Concluding Comment

We maintain that quantitative literacy is a vital competence required by students entering into and for success in higher education. We have presented a definition of quantitative literacy which we have used to construct a specification for a quantitative literacy test. For this purpose we have drawn upon several assessment frameworks currently in us, such as those of the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS) and Adult Literacy and Life (ALL) Skills Survey, as well as the framework in the national Department of Education's Subject Assessment Guidelines for Mathematical Literacy. As mentioned in the section on Academic Literacy, a final decision has yet to be made about the exact form of the assessment framework that will be used for this project.

Domain 2–

Cognitive Academic Mathematical Proficiency (CAMP)
Carol Bohlmann and Max Braun
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Overview

Whereas the Academic Literacy and Quantitative Literacy tests are intended as tests of generic skills in these domains, the Cognitive Academic Mathematical Proficiency (CAMP) test is explicitly designed to measure how well the school exit qualification – the new National Senior Certificate (NSC) – will assess the mathematical preparedness of candidates for higher education by comparing student performance at tertiary level against their performance in the NSC and in the benchmark test.

The term "CAMP" is designed to link with the Basic Interpersonal Communicative Skills/Cognitive Academic Language Proficiency (BICS/CALP) distinction made in relation to Academic Literacy (see pages 20-22). The BICS/CALP distinction plays an important role in all text comprehension. Cummins (1981) postulated the existence of a minimal level of linguistic competence that students must attain in order to perform cognitively demanding tasks. Dawe (1983) further postulated the need for a threshold level of proficiency in what he called CAMP: Cognitive Academic Mathematics Proficiency. Dawe contended that the underlying proficiency needed to complete mathematical tasks involves cognitive knowledge (mathematical concepts and their application) embedded in a language specifically structured to express that knowledge. Research has shown that although second language students may acquire BICS fairly quickly, the acquisition of academic language skills takes an average of five years (see for example Garaway, 1994).

In the Learning Programme Guidelines for the National Curriculum Statement (NCS) for Mathematics for Grades 10 to 12, it is stated that:

> The curriculum for Mathematics is based on the following view of the nature of the discipline. Mathematics enables creative and logical reasoning about problems in the physical and social world and in the context of Mathematics itself. It is a distinctly human activity practised by all cultures. Knowledge in the mathematical sciences is constructed through the establishment of descriptive, numerical and symbolic relationships. Mathematics is based on observing patterns, which, with rigorous logical thinking, leads to theories of abstract relations. Mathematical problem solving enables us to understand the world and make use of that understanding in our daily lives. (DoE, 2005a: 7)

Furthermore, the document states that

> Mathematics should enable learners to establish an authentic connection between Mathematics as a discipline and the application of Mathematics in real-world contexts. Mathematical modelling provides learners with a powerful and versatile means of mathematically analysing and describing their world. ... Mathematical modelling allows learners to deepen their understanding of mathematics while expanding their repertoire of mathematical tools for solving real-world problems. (Ibid., pp.11-12)

The Learning Programme Guidelines for Mathematics emphasise the ability of Mathematics to provide the conceptual tools required to analyse (situations and arguments), make and justify critical decisions, implying that the presence of these attributes carries over into every day life, and has benefits beyond the subject-related ones: "Mathematics is also important for the personal development of any learner. Mathematics is used as a tool for solving problems related to modern society and for accelerating development in societies and economies" (DoE, 2005a:7).

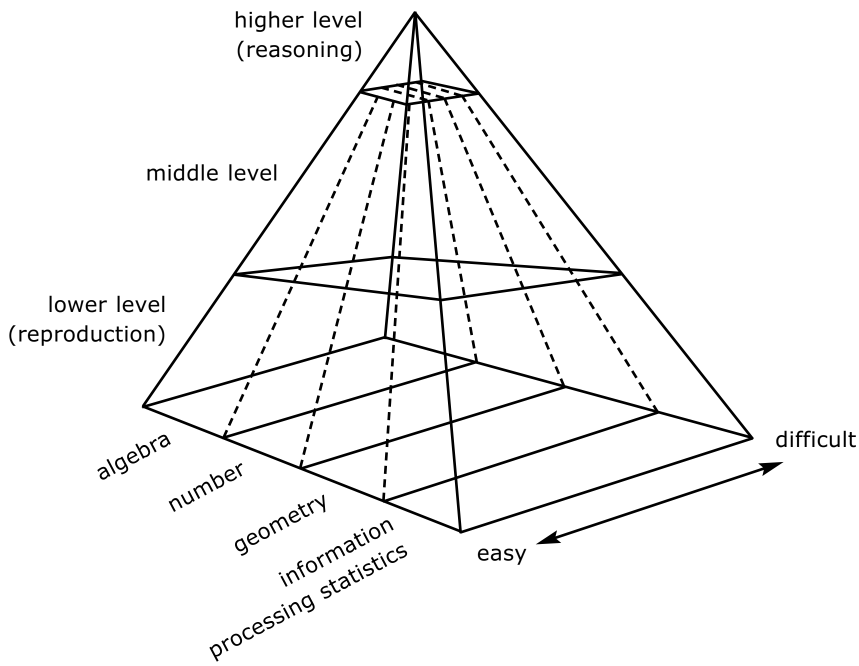
The ability of students to analyse and describe their world mathematically presupposes an ability to comprehend text and formulate principles verbally (academic literacy). Formulating the problem, together with an ability to use mathematical tools to analyse the situation in a meaningful way, constitutes mathematical modelling. After some form of mathematical modelling, however contrived it may be at this level, quantitative reasoning comes into play in the interpretation of answers. Meta-cognitive skills thus also need to be assessed in a mathematical context, if sense making is regarded as an important academic skill.

"Making sense" – whether choosing the right "tools" or coming to the appropriate conclusions using logic in an appropriate context – is critically important for all scientific and health disciplines, as well as being a cornerstone in South Africa's technological vision.

Acceptable assessment practice suggests that assessment tasks should provide balanced problems which are meaningful, informative, set in recognisable contexts, and involve higher order thinking (van den Heuvel-Panhuizen, 1996). One possible categorisation of educational goals into lower, middle and higher levels is provided by de Lange (1994) in Verhage & de Lange (1997). This categorisation is illustrated in Figure 1. In terms of this categorisation, straightforward real-life assessment tasks may be at the lower level, while meaningless but difficult tasks are also lower level activities if they require no insight and simply the application of routine skills. Middle level tasks require that students relate two or more concepts or procedures, and although they may be easier to solve, they are richer and more meaningful than more involved but meaningless routine tasks.

The third level includes other aspects such as mathematical thinking, communication, critical attitude, creativity, interpretation, reflection, generalisation and "mathematising" (Verhage & de Lange, 1997: 16). Freudenthal coined the term "mathematisation" in the 1960s to "signify the process of generating mathematical problems, concepts, and ideas from a real-world situation and using mathematics to attempt a solution to the problems so derived" (Perry & Dockett, 2002: 89). Although Freudenthal's intention was that this process should begin in early childhood, and even if such opportunities may have been lacking during the developmental years, they should not necessarily be excluded later. The important point is that learners should have discovered and learned to use mathematical tools with which they can organise and solve real-life problems.

Figure 1:
Levels of mathematical educational goals



It is important that assessment should enable learners to demonstrate what they know rather than what they do not know; furthermore, assessment should integrate lower, middle and higher level goals of mathematical education (see Figure 1 above).

It is thus clear that the CAMP test needs to assess the development of some level of rigorous logical thinking, as well as the development of the skills and tools required to use mathematical concepts to solve real world problems. The mathematical tools used in the exercise of logical thinking and the knowledge and skills required to solve problems would be expected to have been provided by the secondary school curriculum, and problem solving would involve concrete everyday situations in which such ideas may be relevant.

The minimum requirements indicated in the Subject Assessment Guidelines of the National Curriculum Statement for Mathematics for Grades 10–12 provide information regarding the level at which content-based aspects could be measured. Test items will also be influenced by the taxonomy of categories of mathematical demand specified in the Subject Assessment Guidelines, which indicates that learners need to:

- perform on the levels of knowing (recall, or basic factual knowledge are tested);
- perform routine as well as complex procedures; and
- engage in problem solving (see the Subject Assessment Guidelines, DoE, 2005b: 26–28).

The Learning Programme Guidelines for Mathematics point out that "the process skills developed in Mathematics are those that enable learners to become mathematicians as opposed to stunting their growth through an emphasis on rote approaches to the subject"; and furthermore, that "A learner who achieves the Assessment Standards for Mathematics will be well prepared for the mathematics required by Higher Education Institutions" (DoE, 2005b: 8). This view is welcomed by higher education, where rote learning has for so long undermined learners' progress. It is thus important to measure the extent to which this has been achieved at entry levels to higher education study. The CAMP test thus needs to assess the extent to which the new schools curriculum has prepared students with both low- and high-level skills that equip them to engage with abstract mathematical concepts and their real-life applications. As in the other tests, the CAMP test needs to take into account student diversity and accommodate differences in the ways that students think and demonstrate their knowledge and skill. The CAMP test needs to reflect the vision of the Learning Programme Guidelines which highlights the interrelatedness of content, processes and contexts (see Figure 2.3 in the Learning Programme Guidelines: Mathematics (DoE, 2005b: 13).

The Specific Role of the CAMP Test

It is important to clarify the specific role of the CAMP test in relation to the Academic Literacy and Quantitative Literacy tests. The Academic and Quantitative Literacy tests determine the degree to which essential skills for a school-leaver and functional participant in higher education have been obtained from prior learning opportunities in verbal and numerical contexts. The Mathematics test assesses the degree to which a learner has achieved the ability to manipulate, raise questions, synthesise a number of different mathematical concepts and draw strictly logical conclusions in abstract symbolic and complex contexts. These higher skills underlie success in Mathematics in higher education. These skills, developed deliberately in mathematical subjects such as Mathematics and Physical Science, are often implicitly expected by higher education institutions and are included in the design of courses or modules satisfying outcomes-based education norms. Where candidates for higher education programmes have not been exposed to the specific mathematics concepts that could reasonably be expected to be included in the Mathematics test (for reasons such as inadequate or disrupted schooling), some of the generic skills must be assessed in the more concrete contexts of the Academic Literacy and Quantitative Literacy tests. Some overlap between the three test components may therefore be expected, but it is also evident that the contexts of the tests should be appropriately different.

Source of skills and competencies that the CAMP test must address

In the design of CAMP test items, it will be important to:

- interrogate the outcomes specified in the Mathematics subject statement in order to make certain that these are covered in the CAMP; and
- consider the mathematical concepts required in higher education programme contexts requiring mathematics.

The Nature of the Test

The focus is on achievement/proficiency but it is necessary to construct richly contextualised tests that are sensitive to the diversity of candidates in terms of their levels of preparedness.

Equity in assessment is related to equity of resources (Mathematical Sciences Educational Board (MSEB), 1993). The test items would thus need to make provision for diversity in terms of ethnicity, language, urban/rural and socio-economic status (Tate, 1997). Some dynamic components are necessary if learning ability (rather than only past achievement) is to be assessed. However, dynamic test items would probably only be included once more standard items have been adequately piloted.

It is important that assessment should reflect mathematical goals, so that skills are assessed at different levels, that is, low, middle and high (Verhage & de Lange, 1997). In the design of the test scoring may need to make provision for a number of sub-minima, or a weighting of questions, so that high scores on low-level skills do not contribute in the same way to the over-all profile of students as high-scores on high-level skills. Testing for understanding should carry more weight than assessing the extent to which concepts could have been memorised (see also Lawson, 1995; Mason, 2002; Kahn & Kyle, 2002).

To provide learners with a smooth interface between Mathematics at secondary and tertiary level, the competencies that are required, but not necessarily made explicit, by higher education need to be assessed. The choice of competencies is also influenced by the four Learning Outcomes (LO1, 2, 3 and 4) that appear in the Learning Programme Guidelines[6] of the National Curriculum Statement for Mathematics for Grades 10-12:

- Number and number relationships;
- Functions and algebra;
- Shape, space and measurement; and
- Data handling and probability.

These are the outcomes that will be assessed in Grade 12 in 2008, 2009 and 2010. Table 4 outlines the competencies that will be assessed in the CAMP test.

[6] The document is available on the following website: http://www.education.gov.za/mainDocument.asp?src=docu&xsrc=poli.

Table 4:
Definition of Competencies that should be assessed in the CAMP Test

Competence	Specific aspects assessed
Problem solving and modelling within mathematical contexts:	operations with fractions and decimals; operations involving abstract relationships such as ratios, percentages and powers; interpretation of scientific notation; orders of magnitude; number sense; quantitative comparisons
	spatial perception including angles, symmetries, measurement, representation and interpretation of 2D and 3D shapes
	functions represented by tables, graphs and symbols; distinction between dependent and independent variables; relationship between graphs and algebraic equations and inequalities; functions and their inverses, e.g. the relationship between ln and e^x; recognise and apply functional relations, such as direct and inverse proportion, in a variety of ways; understanding of above/below, e.g. approaching from above, from below; translation between different methods of representation of functions
	operations with surds
	circle geometry
	basic trigonometry, including graphs of trigonometric functions
	solving for unknown quantities in single and simultaneous linear, quadratic equations, and simple polynomial expressions and inequalities
	using common statistical measures (mean, median, mode, range)
	pattern recognition (as in sequences and series)
	conversion from language to symbolic form, e.g. the common interpretation of “I earn 25% less than you” as “you earn 25% more than me”; confusion between “x times more than y”, and “x more than y”

Competence	Specific aspects assessed
Manipulation of formal conditional, biconditional and contrastive statements; interpretation of inferences (logic of theorems, converses, definitions)	identify appropriate evidence to support a claim or an argument
	critique assumptions and thinking which underlie logical argument
	evaluate the validity of evidence used to support claims
	tentative or conclusive reasoning
	see logical relationships between statements; construction of all possible combinations or conditions
	understand the concept of "chance" and probability and draw inferences within them
	Algebraic manipulation ability to perform basic manipulation of algebraic expressions

There is clearly an overlap with the other domains. The overlap emphasises the importance of the achievement of a threshold in Academic and Quantitative Literacy skills in order for learners to cope with the conceptual demands of the mathematical domain. In the CAMP test competencies will be assessed within a specific mathematical context, so that the item content will be essentially different to that of items in the AL/QL domain. Learners who have inadequate grounding in the competencies described above are unlikely to cope with mathematics at tertiary level. The fact that mathematics requires learners to integrate many different skills and concepts in a given problem means that individual test items will assess across the range of mathematical competencies. For example, an item dealing with the graphical representation of a function will also assess spatial and algebraic competence. Test items will focus specifically on the following clusters: algebra, trigonometry, geometry and spatial awareness; and logarithms, exponents and surds. Mathematical concepts will be assessed within a context of deep understanding, with an emphasis on the ability to move between different forms of mathematical representation.

Concluding Comment

There are many relevant assessment frameworks for mathematics, such as those used by the Programme for International Student Assessment (PISA), and the Trends in International Mathematics and Science Study (TIMSS) Assessment Frameworks. The Subject Assessment Guidelines of the National Curriculum Statement for Mathematics for Grades 10-12[7] propose a taxonomical differentiation of questions in which knowledge, performance of routine procedures, performance of complex procedures and problem solving carry weights respectively of approximately 25%, 30%, 30% and 15%. At this stage no final decision has been made regarding the balance of items in the CAMP test, as the test development team is currently assessing the appropriateness of initial test items and the effectiveness of feasible approaches to assessment.

[7] The document is available on the following website:
http://www.education.gov.za/mainDocument.asp?src=docu&xsrc=poli.

Appendix 1

TEST ITEM DEVELOPMENT TEAM MEMBERS, 2005

REFERENCE GROUP NATIONAL BENCHMARK TESTS PROJECT CONSULTATIVE MEETING 25 NOVEMBER 2004

Test Item Development Team Members, 2005

Academic Literacy	
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Reference Group
National Benchmark Tests Project Consultative Meeting
25 November 2004

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Koo Parker	Durban Institute of technology
Shubnam Rambharos	Durban Institute of Technology
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Prof Nan Yeld	University of Cape Town	

SAUVCA & CTP Directorates

Hanlie Griesel
Ronnie Kundasami
Cobus Lötter
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Gladness Seabi

Appendix 2–

ELABORATION ON THE ELEMENTS OF THE DEFINITION OF QUANTITATIVE LITERACY

Vera Frith and Robert Prince
Centre for Higher Education Development, University of Cape Town

Definition

> Mathematical literacy is the ability to manage situations or solve problems in practice, and involves responding to quantitative (mathematical and statistical) information that may be presented verbally, graphically, in tabular or symbolic form; it requires the activation of a range of enabling knowledge, behaviours and processes and it can be observed when it is expressed in the form of a communication, in written, oral or visual mode.

Elaborations on the elements of the definition of quantitative literacy

To make the definition of quantitative literacy more explicit, we elaborate on what is meant by the following concepts in the definition: "real contexts", "responding", "quantitative information", "representation of quantitative ideas", "activation of enabling knowledge, behaviours and processes" and "expressions of quantitatively literate behaviour".

Working in a real context

An important component of quantitative literacy, often mentioned in the literature, is the ability to operate in a context. The following elaboration of the different types of contexts for exercising quantitative literacy is largely based on the discussion in Steen (2001: 12-14).

1) Education in a tertiary context

Significant mathematical competence has always been required in order to study most scientific, commercial and engineering disciplines. However, it is becoming increasingly necessary for students in these disciplines, as well as those in other, traditionally less mathematically-demanding disciplines such as social studies or law, to develop high levels of quantitative literacy. Some examples follow:

- Social sciences such as sociology or psychology "rely increasingly on data either from surveys and censuses or from historical or archaeological records; thus statistics is as important for a social science student as calculus is for an engineering student" (Steen, 2001: 12).
- In a discipline like history, a student may need to understand and perform summary analysis of descriptive and numerical data and records.
- Students studying medicine need high levels of quantitative literacy to understand, for example, experimental studies, surveys, assessment of risk, epidemiology and other aspects of public health, and in the explicit practice of diagnostic reasoning.
- Law students similarly need, for example, to understand arguments based on evidence using DNA testing, to understand financial management, and to understand evidence gathered using social science methods.
- Biology students would need (as for medicine) to be able to think probabilistically and to use and understand statistics, as well as more traditional mathematics.
- Students in some areas of the visual arts and media studies will need a level of quantitative literacy to realise the potential of technology in their discipline (for example in computer graphics and animation).

2) Professions

Almost all professions require the ability to deal with quantitative evidence to make decisions, as quantitative data becomes increasingly important and ubiquitous in modern society. For example:

- Lawyers exercise various kinds of subtle reasoning and arguments about probability to argue their cases and make statements about "reasonable doubt".
- Doctors need to understand statistical arguments in order to explain risks clearly enough to patients to ensure "informed consent". As part of diagnosis they need to be able to formulate tentative inferences about plausible causes from information about the presence or absence of effects.
- Journalists need a thorough understanding of quantitative information and arguments, to develop an informed, skeptical and responsible understanding of events in the news, and to be able to modify this view as necessary when new information unfolds.

3) Personal Finance

People in society, particularly if self-employed, need to understand complicated quantitative issues such as depreciation, inflation, interest rates over different periods of time, the effect of variations in loan repayments, risk on investment, gambling, the tax implications of different financial decisions, bank charges and so forth. "In everyday life a person is continually faced with mathematical demands which the adolescent and adult should be in a position to handle with confidence. These demands frequently relate to financial issues such as hire-purchase, mortgage bonds and investment." (DoE, 2003: 9)

4) Personal Health

With the increasing role of quantitative data in the field of medicine, quantitative literacy has become increasingly necessary for people to manage their personal health. Patients need to understand statistics and probability to understand the tentativeness of diagnoses, the fallibility of medical testing, the choice of different treatment options and the risks associated with them. Sufficient knowledge of finances is needed to balance the costs and benefits of new treatments, to understand medical aid schemes and to manage payments for medical services and insurance. People using medication need to understand dosages which are calculated in proportion to body weight, or which must be administered according to a precise timing regime.

5) Management

Different people carry out management tasks in a variety of different settings, such as home, travel, school, business, societies, committees and other enterprises. Some examples of management activities requiring quantitative literacy are:

- developing a business plan.
- gathering and analysing data (e.g. for tracking expenditures).
- looking for the presence or absence of trends in data to make predictions (and understanding the limits of extrapolation).
- drawing up or reviewing budgets and balance sheets.
- calculating time differences and currency exchange.

6) Workplace

"The workplace requires the use of fundamental numerical and spatial skills in order efficiently to meet the demands of the job. To benefit from specialised training for the workplace, a flexible understanding of mathematical principles is often necessary. This numeracy must enable the person, for example, to deal with work-related formulae, read statistical charts, deal with schedules and understand instructions involving numerical components" (DoE, 2003: 9). Other representative tasks are: completing purchase orders, totaling receipts, calculating change, using spreadsheets to model scenarios, organising and packing different shaped goods, completing and interpreting control charts, making measurements and reading blueprints. (ALL, 2002:17)

7) Citizenship

"To be a participating citizen in a developing democracy, it is essential that the adolescent and adult have acquired a critical stance with regard to mathematical arguments presented in the media and other platforms. The concerned citizen needs to be aware that statistics can often be used to support opposing arguments, for example, for or against the use of an ecologically sensitive stretch of land for mining purposes. In the information age, the power of numbers and mathematical ways of thinking often shape policy. Unless citizens appreciate this, they will not be in a position to use their vote appropriately." (DoE, 2003: 10)

Some examples of relevant situations involving quantitative literacy are:

- understanding how voting procedures can affect the results of an election.
- understanding the concept of risk and its measurement.
- understanding that apparently unusual events can occur by chance.
- analysing data to support or oppose policy proposals.
- understanding the difference between rates and changes in rates (for example, the meaning of a reduction in the rate of inflation).
- understanding weighted averages, percentages and statistical measures such as percentiles (for example, in data about performance of educational institutions).
- appreciating common sources of bias in surveys such as poor design and non-representative sampling.
- understanding how assumptions influence the behaviour of mathematical models and how to use models to make decisions.

8) Appreciation for mathematics as part of human culture

As part of their education, people should learn to appreciate the roles mathematics plays in our society and economy. They should recognise the power (and dangers) of numbers in decision-making and influencing people's opinions. Ideally they should understand the historical significance of fundamental mathematical concepts (such as zero and place value), and how the history of mathematics relates to the development of cultures. "As educated men and women are expected to know something of history, literature, and art, so should they know – at least in general terms – something of the history, nature, and role of mathematics in human culture" (Steen, 2001: 11).

Responding

There are four categories of competency involved in responding to a situation or problem in a quantitatively literate manner (displaying quantitatively literate behaviour):

- identifying or locating: the nature of the situation/problem is comprehended and the appropriate actions are explicitly recalled and conceptualised.
- acting: the appropriate actions are carried out.
- interpreting: the meaning of the outcome of the activities is interpreted in the context.
- communicating: the consequences or meaning are communicated appropriately for the context.

These four types of activity are not carried out chronologically. A person uses these competencies in an integrated and iterative way while engaging with a quantitative situation or problem.

1) Comprehending the situation or problem

In order to gain access to the quantitative information embedded in a situation or problem, a person may need to:

- know the meanings of terms and phrases used to express quantitative ideas (appropriate text literacy).

- know the necessary mathematical and statistical concepts.
- know the conventions for representation of numbers, operations and variables.
- know the conventions for representation of data in diagrams, charts, tables and graphs.
- know the conventions for the representation of 2-dimensional and 3-dimensional space.
- identify the relevant quantitative actions in which to engage.

2) Acting on the situation or problem

In engaging with a quantitative event a person may need to:

- perform calculations using commonly encountered operations.
- estimate the magnitude of answers to simple calculations.
- visualise and/or model situations using simple formulae and/or diagrams.
- arrange "quantitative objects" in order.
- identify where to find and extract information from representations of data.
- locate the necessary information from more than one unspecified source, and use it in combination.

3) Interpretation: Making sense of the situation or problem

Competencies required for interpreting quantitative information include the ability to:

- ask appropriate questions and formulate conjectures.
- understand the quantitative information in terms of the context in which it is embedded.
- identify absences of possibly relevant information.
- reason logically (linking evidence and claims); i.e.
  - identify whether a claim is supported by the available evidence, or whether future corroborative evidence is needed.
  - formulate conclusions that can be made given the evidence.
  - identify the evidence necessary to support a claim.
- translate between different types of representation of the same data.
- recognise the presence of patterns and permutations in data.
- identify relationships revealed by data.

4) Communicating about the situation or problem

In order to communicate about quantitative information a person often needs to:

- represent quantitative information verbally, visually (in charts graphs or diagrams), in tabular form or using symbols (including in formulae)
- identify ambiguities or omissions in representations.
- describe comparisons between data values, trends and relationships.
- explain reasoning (linking evidence and claims).

Quantitative information (fundamental mathematical and statistical ideas)

The following classification and description of the fundamental ideas which underpin the definition of quantitative literacy are largely based on the ALL (2002: 18-20) and the PISA (2003: 36-37) frameworks.

1) Quantity, number and operations

Classification, ordering and quantification (using numbers) is fundamental to the process of making sense of and organising the world. Whole numbers are used for counting, measuring and estimating; fractions are needed to express greater precision, ratios for making relative comparisons and positive and negative numbers for expressing direction. Numbers are also fundamental to the processes of ordering and labelling (e.g. telephone numbers and postal codes) and calculating. A very important part of quantitative literacy is the possession of a good "sense" of magnitude and the ability to judge the required level of accuracy in a given context, and to assess the consequences of any inaccuracies.

2) Shape, dimension and space

The study of shapes is connected with the ability to know, explore and move with understanding in the real space in which we live. This ability requires understanding the spatial properties of objects and their positions relative to each other, as well as how they appear to us. We need to understand the relationships between shapes and images (for example the representation of three-dimensions in a two-dimensional image). The ideas of dimension and space involve the visualisation, description and measurement of objects in one, two or three dimensions (projections, lengths, perimeters, surfaces, location) and requires the ability to estimate and to make direct and indirect measurements of direction, angle, and distance.

3) Relationships, pattern, permutation

The capacity to identify patterns and relationships is fundamental to quantitative thinking. Relationships between quantities can be represented through the use of tables, charts, graphs, symbols and text. The ability to generalise and to describe relationships between variables is essential for understanding even simple social or economic phenomena, and is fundamental to many everyday quantitative activities. Patterns or relationships that involve the dimension of time require particular attention, as they are so fundamental to our experience of the world (seasons, tides, days, phases of the moon and so on).

4) Change and rates

The concept and measurement of time intervals is fundamental to understanding changes that occur over time. Change is inherent in all natural phenomena, and we are surrounded by evidence of temporary and permanent relationships among phenomena. Individuals grow, populations vary, prices fluctuate, objects traveling speed up and slow down. The measurement of rates of change (and changes in rate of change) help provide a description of the world as time passes.

5) Data representation and analysis

The idea of "data" includes ideas such as variability, sampling and error, and statistical topics such as data collection and analysis, data displays and graphs. People are often required to interpret (or produce) analyses and representations of data, such as frequency tables, charts (such as pie and bar charts) and descriptive statistics, (such as averages).

6) Chance and uncertainty

The idea of "chance" is expressed mathematically in terms of probability. Competence in this area involves the ability to attach a number to the likelihood (or risk) of an uncertain event. Being able to understand statements about and to reason with probabilities is necessary, for example, in understanding weather forecasts, financial and social phenomena, legal arguments and health risks.

Representation of quantitative ideas

When a person engages with a real situation or a problem of a quantitative nature (a quantitative event), the information needed can be presented in many different forms, including:

- symbols (numbers, variables or formulae).
- words (verbal or written texts, using ordinary words or specialised terminology, or special formats such as forms).
- tables and charts (tables of data, bar, pie, line and other charts or graphs).
- objects or pictures (objects to be counted, visual displays, scale models, diagrams or maps).

Activation of enabling knowledge, behaviours and processes

The way in which a person will respond to a quantitative event will depend on her/his quantitative knowledge and skills, quantitative reasoning ability, literacy skills and beliefs and attitudes. These are briefly discussed below.

1) Quantitative (mathematical and statistical) knowledge and skills

Mathematical and statistical knowledge, including the understanding of mathematical concepts and access to computational skills and procedures, is the basis for being able to manage many quantitative tasks in real life (ALL, 2002: 20) and for comprehending the significance of these tasks. The description of these skills and procedures is structured in many different ways in different school curricula and they may be assessed in surveys such as TIMMS and PISA. For example, one possible structure is a breakdown of the knowledge and skills into those related to whole numbers, fractions, decimal representation of fractions, measurements, differences, directions, ratios, percentages, rates, geometry, use of the Cartesian plane, algebra, descriptive statistics and probability.

2) Quantitative reasoning

Reasoning quantitatively involves the capacity for logical, systematic thinking (Mullis et al, 2003: 32). It includes intuitive, inductive, deductive and probabilistic reasoning. For example, reasoning involves the ability to observe patterns and regularities and make conjectures, as well as the realisation that incomplete evidence or inherent uncertainty could lead to tentative inferences which may later be found to be erroneous as further evidence unfolds. It also involves making logical deductions based on specific assumptions and rules, identifying and using evidence required to support a claim, as well as identifying claims that are supported/not supported by given evidence. The ability to generate counter-examples to disprove a claim is also included.

The TIMSS framework (Mullis et al, 2003: 32-33) specifies the following sub-categories under this heading:

- hypothesise/conjecture/predict (e.g. make conjectures by investigating patterns and trends revealed in tabulated data.)
- analyse (e.g. applying relevant statistical analysis to a set of data; extracting information from a situation for which a quantitative activity is relevant.)
- generalise (e.g. given a set of data that shows a specific relationship exists for several different years, formulating the statement that the relationship may exist at all times.)
- connect (e.g. translating quantitative information from one representation to another, making connections between related quantitative ideas or objects.)
- synthesise/integrate – combine disparate procedures or results to form a new result (e.g. combining information from two separate charts to solve a problem.)
- solve non-routine problems (e.g. applying quantitative concepts and procedures familiar from one context to a new unfamiliar context.)
- justify/prove (e.g. identifying evidence from a chart for the validity of a quantitative statement; explaining why a given statement about a chart is not supported by the evidence in the chart.)
- evaluate (e.g. commenting on a survey with obvious flaws such as too small a sample or non-representative data.)

3) Literacy skills

Understanding representations of quantitative information will depend on reading comprehension and other literacies. The text associated with a quantitative event usually requires a more analytical reading style than is needed for ordinary prose. Specific literacy is required for analysing mathematical and statistical relationships described in text and for understanding the specialised terminology used to describe quantitative concepts and contexts. Making sense of mathematical or statistical information represented in textual form requires the understanding and correct use of seemingly basic terms like "greater than, smaller than, percentage, half of, more than double" as well as terms used for more complex mathematical and statistical information, such as "significant difference", "weighted average", "function of", "change of rate", "random sample", "probability" and "correlation". In a similar way, understanding quantitative text often requires visual literacy associated with interpreting and creating diagrams, maps, charts, graphs and other visual representations.

4) Use of computational technology

Quantitative literacy includes the ability to make use of and understand the role of computers in science, social science, professional and everyday life, and in the workplace. "The changing nature of workplaces and the ubiquity of computer-based systems for the automation and control of processes and the management of information, has brought about the need for employees at all levels to engage with these systems, to interpret their outputs and to make sense of the abstract models on which they are based" (Kent, Hoyles, Noss & Guile 2004: 1). At its most fundamental level this knowledge includes the role and use of calculators and in the context of tertiary education includes the effective use of spreadsheets (Frith, Jaftha & Prince, 2005).

5) Beliefs and attitudes

Affective factors play a particularly significant role in people's ability to engage productively with quantitative events. "The way in which people respond to a quantitative situation and how they choose to act depends on how familiar they feel with such situations and how confident they are in their own strategies. General dispositions towards mathematical matters, as well as a person's self-perception and the degree of a sense of "at-homeness" with numbers, considerably impact a person's willingness and ability to perform mathematics tasks." (ALL, 2002:22). In fact the National Curriculum Statement for the subject Mathematical Literacy (DoE, 2003: 9) specifies the development of confidence as part of its definition of the subject area. We have discussed the role of confidence in mathematics learning in Frith, Jaftha & Prince (2004b).

Expressions of quantitatively literate behaviour

Quantitative literacy can be expressed when a person responds to a quantitative event by producing a written, oral and/or visual (including concrete objects) text. The notion of "text" is used broadly (see Archer, Frith & Prince, 2002) and includes many kinds of output, including concrete objects.

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