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SUMMARY

In the mid-1980's institutions of higher learning were coerced by the South African government to admit students from all races. As a result, these institutions were confronted with the need to identify preparedness for higher learning, especially amongst the ex-Department of Education and Training (DET) learners. Grade 12 results were not a sufficient predictor for ex-DET learners, and a review of current admission criteria became a necessity.

This study aims to develop a suitable science entry-level test to be used as a component of an existing test battery. The test battery is used as an admission tool by the Port Elizabeth Technikon to further assess first year applicants who do not meet the normal entrance requirements for a science course. The only requirement for further assessment being Grade 12 physical science.

The science entry-level test consists of a list of validated science skills and knowledge to be used to assess the skills and knowledge mastered at the time of test taking. On the basis of test scores, an assessment is made regarding the applicant's preparedness for higher learning.

This study holds the view that preparedness in students for higher learning in science can be measured by means of valid science competencies. In addition, knowledge of the level of preparedness of the applicant enables further educational support and guidance to be provided where necessary. Research which measures manifest academic ability rather than potential to learn is favoured since it is believed that the former generates psychometric evidence of that which was already mastered academically whilst the latter determines whether the student will be able to achieve under ideal conditions.

The content covered by the proposed Science Competency Test was sanctioned by technikon lecturers of first year physics and chemistry courses. The content was taken from the examinable section of the Grade 11 and 12 physical science syllabi. This content is the most acceptable and fair knowledge-base a prospective science student can be expected to have mastered at school. The content was limited to those skills and knowledge believed by the lecturers to contribute to academic success in the first year.

Items that tested this content were compiled and pilot tests were administered to Grade 12 physical science learners at various disadvantaged schools.

The Science Competency Test was compiled from the pool of trial items after the performance of the items was statistically determined. This final Science Competency Test was completed by a sample of 179 first-time first year science students.

The findings of the study were inconclusive as the Science Competency Test showed a moderate predictive ability for only one section of the sample. It further showed that the weighted matric score, WMS was not a significant predictor of future academic performance of the sample either. A discrepancy in performance amongst learners of different home languages and educational backgrounds was also noted.

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THE DEVELOPMENT OF A SCIENCE COMPETENCY TEST FOR TECHNIKON STUDENTS

BY

SAMIEGA DAVIDS, BSc, HDE, BEd

Dissertation submitted in compliance with the requirements for the Master's Degree in Technology: Education in the Department of Education at the Port Elizabeth Technikon.

PROMOTER: **PROF. D.W. SHARWOOD**
CO-PROMOTER: **DR. R. GERBER**

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CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

The primary motivations behind the current restructuring of education in South Africa are to uplift and educate its mostly illiterate and semi-schooled population (SA Yearbook 2001/02), to supply it with a skilled workforce and to bring about equity in education (Malala 2000). A national response to this transformation process is evident in the surge in higher learning as reported in SA Survey 2000/01. Public tertiary enrolment doubled between 1985 and 1998 (Huysamen 1996, Warren 1998). The consequence of which was the need to refine the screening of first year applicants (Botha 2000, Botha & Cilliers 1999) and many institutions are exploring alternative screening methods. In line with this academic trend this study aims to develop a suitable science entry-level test.

This dissertation is a report of the process followed in developing the science entry-level test.

An outline of the six chapters is as follows:

Chapter 1 outlines the area and problem statement of the research.

Chapter 2 gives a review of existing literature with regard to admission testing. The theoretical and conceptual frameworks of the research are explained.

Chapter 3 describes the experimental methodology used in developing the science entry-level test. The pilot testing, analysis of the test items and the compilation of the final test are explained.

Chapter 4 focuses on the Science Competency Test. A breakdown of the developed test into its various sections, statistical parameters that guided the item selection process and the item selection process are elaborated upon.

Chapter 5 discusses the results and interpretations of the statistical analysis of the test.

Chapter 6 summarises the main findings of the research and offers recommendations for future research endeavours.

1.2 FOCUS OF THIS STUDY

The primary purpose of this research is to develop an entry-level test, specifically a science entry-level competency test. It encompasses science skills and knowledge to be used in a test battery by the Port Elizabeth Technikon as part of the screening process for the following courses: Analytical Chemistry, Biomedical Technology, Environmental Health and Rubber Technology.

The secondary purpose of the research is to measure preparedness for higher education in terms of the science skills and knowledge the applicant has mastered at the time of test

taking. The test will be used to quantify preparedness for higher education in all applicants including those from non-traditional educational backgrounds.

Test scores will facilitate categorization of applicants as:

1) Prepared for higher education: those who scored well in the test and thus have the necessary science skills and knowledge to succeed in a science course. These applicants will gain admission into mainstream.

2) Under-prepared for higher education: those who scored below the cut-off, but within a set margin. These applicants have a reasonable chance to succeed at higher education with the aid of educational intervention.

3) Not prepared for higher education: those who scored very low in the test and thus do not have the science skills and knowledge needed to succeed at higher education. This group will be denied entry and channeled elsewhere.

This research aims to show that the Science Competency Test will be a better predictor of academic performance for the science courses mentioned, especially in the areas where the Grade 12 results failed to yield any predictive value.

1.3 STATEMENT OF THE PROBLEM

The South African school system has, to a large extent, failed to develop the full potential of most of the ex-Department of Education and Training (ex-DET) learners and rendered most under-prepared for higher learning (Bawa 1993, Huysamen 1997, Griesel 1992, Miller 1992, Yeld & Haeck 1997). Consequently, most ex-DET learners do not meet the necessary entry requirements to institutions of higher learning, and those who are admitted have a high failure and drop-out rate.

The Port Elizabeth Technikon (PET) has a Pre-Technician programme to prepare students for science and engineering courses. Applicants who do not meet the full entry requirements

for a science course, and who have mathematics and physical science at Grade 12 level, are admitted to this programme. Through the assistance of this programme many of the ex-DET students and other students have successfully gained entrance into mainstream science and engineering courses the following year.

Through the Pre-Technician programme, it was discovered that although these students did not meet the entrance requirement, they did possess the ability to achieve academically. The educational support provided by the Pre-Technician programme upgraded their educationally deprived status enabling them to achieve in further study. These students were merely under-prepared for higher education.

The problem is in identifying under-preparedness from the outset. Invariably, the applicant's Grade 12 results are weak and they do not meet the entry requirement. Instead of rejecting these learners, the PET is seeking a solution to identify those having the potential to succeed.

The aim of this study is to develop a test that will aptly reflect their level of preparedness. The proposed Science Competency Test is offered as a means of identifying those under-prepared learners with the potential to succeed academically.

1.4 SUB-PROBLEMS

Six sub-problems were identified by the researcher and are listed as:

- To identify the core competencies i.e. science skills and knowledge, needed to succeed in the first year of study.
- To develop a test to assess the science skills and knowledge identified by the research.
- To develop a test instrument that will prove a reliable and valid measurement tool for under-prepared students (especially in terms of criterion-related validity) .
- To develop a test instrument that will be fair to all subgroups/test takers.

- To set selection standards i.e. to set cut-offs and place the sample in groups of the Prepared, Under-prepared and Not prepared.
- To interpret the test results.

1.5 HYPOTHESIS

A Science Competency Test can be developed to predict the success of students in science courses at the PET.

1.6 DELIMITATIONS OF THE RESEARCH

The delimitation of this research places limitations on the main problem thus making it more manageable from a research perspective. The following three delimitations are mentioned.

- The test measures only the core competencies (skills and knowledge) identified in the research as contributing to success in the first year of study.
- Subjective factors such as motivation, creativity and interpersonal skills are not measured by the test.
- The test covers only those sections of the Grade 11 and 12 physical science syllabi that are examinable in the Grade 12 final examination.

1.7 ASSUMPTIONS OF THE RESEARCH

In this study it is assumed that:

- The core competencies needed to succeed at science can be identified.
- It is possible to develop a test that will be a reliable measure of the core competencies a student has at the time of test taking.

- Learners have completed the Grade 12 physical science syllabus or have an equivalent qualification.
- Although mathematical skills are not assessed, science students have elementary mathematical skills.
- All test takers are able to use a calculator.
- All test takers are able to read, write and understand the English language, which is the language of the test.
- The trait of science ability can be measured by means of a test instrument.
- The trait of science ability exists within the test taker.

1.8 SIGNIFICANCE OF THE RESEARCH

The Port Elizabeth Technikon is an institution that feeds the labour market with the skills required and in so doing assures growth in the economy of the country. As such, it seeks to increase the throughput rate of first year science students. This has become very important to the Port Elizabeth Technikon and South Africa for a number of reasons. There is a dire shortage of people skilled in the areas of science and technology. The Education White Paper 3 (August 1997) highlights the shortage as an area where redress should occur and further states that South Africa is lagging behind the rest of the world in science and technology.

An increase in the throughput can be achieved by increasing the number of students admitted and by ensuring that those who are admitted succeed at their studies.

1. An increase in the number of admissions can be achieved by:

- Implementing alternative entrance criteria: School performance alone should not be used as an indication of the academic preparedness for higher learning of the previously disadvantaged learners. Its use has kept the disadvantaged from being selected thus far and the Pre-Technician programme has shown that some are able

to benefit from further education. Alternative entrance criteria that would better predict the future academic performance of this group will achieve a growth in numbers.

- Implementing more relaxed entrance criteria together with academic intervention programmes to prepare the students for mainstream studies. The Port Elizabeth Technikon is already implementing this strategy and has reported notable successes (Sharwood 1998).
- A battery of entry-level tests designed to measure a group of abilities needed to succeed in the first year of study can provide an equitable, easily administered and practical tool for the selection of large numbers of students. The Senate of the Port Elizabeth Technikon has proposed that a battery of tests be developed to identify those students who are prepared for higher education.

2. Thoroughput can be increased by:

- Predicting future academic performance as accurately as possible. Success in any course does not rely on a single ability, but a group of specific abilities which are measured by the test battery. Together the group of abilities makes up the 'preparedness' of the student for a specific course. This measurement of a group of abilities is more comprehensive in comparison to the use of only Grade 12 results, or the selection of students on demographical considerations only.

- Offering educational intervention that focuses on the weaknesses of the students and consolidates their strengths. The information of the weaknesses and strengths of the students can easily, fairly and objectively be obtained from a profile of scores of a test battery. In other words, the entry-level tests can be used to improve the Port Elizabeth Technikon's Pre-Technician programme's syllabus.

Impetus for the development of a science entry-level test as part of a test battery snowballed and was endorsed by the following:

- The Education White Paper 3 (August 1997) stipulates that admissions policies should recognise prior learning and that several alternative routes to higher education should be established. A test of science competencies could prove invaluable in identifying preparedness in those students evolving from non - traditional educational backgrounds.
- A summary of the strengths and weaknesses of the students as reflected by the test scores could be channelled back to schools. This can serve the dual purpose of opening up communication between schools and institutions of higher learning about which areas of the physical science syllabus need to be emphasised in teaching, and in so doing produce better first year students.
- Applicants will know from the outset whether they have the competency to succeed in their studies.
- According to Scott (1992, p.90) 'to avoid wastage of human and material resources and to facilitate equity in access to higher education, there is a pressing need to develop an effective, equitable and practicable selection system which can be applied on a broad scale, without unrealistic reliance on extra resources or specialised skills'.
- A test battery will yield objective scores on the basis of which students will be selected, which in turn will negate the practice of preferential admission on the basis of privileged school background (Mehl 1992).
- The University of Fort Hare has a very lenient admissions policy (Cintsa 1992). The admission requirement is a Grade12 certificate and for certain courses, such as science, the Swedish rating system is used. It reported a failure rate of 67% for the period 1984 - 1991, because the students of the University of Fort Hare are generally under-prepared (Vera 1992). It would be more sagacious to determine the preparedness of applicants than to admit indiscriminately.
- Asmal (2002) states that only 15% of Africans (Blacks) who enter higher education, complete their studies.

1.9 MOTIVATION

There is national motivation from academics and the Government alike for the type of research undertaken. The National Commission on Higher Education (NCHE) (1996:70), advises the Minister of Education to: ' examine the feasibility of developing selection test(s) at a national level to inform the selection of students into Higher Education programmes'.

The Education White Paper 3 (August 1997) discusses the proposed restructured higher education and points out that students of varying ages from traditional and non-traditional educational backgrounds will be admitted to higher education. There is a growing number of students who apply to local higher education institutions from foreign countries, especially Southern Africa Development Countries. These students will have diverse learning experiences and will enter higher education with either a Grade 12 certificate or an equivalent qualification based on the National Qualifications Framework (NQF). Not all students would have studied traditional school subjects. With all this in mind, the individual institutions will have to identify those students with the correct combination of science skills and knowledge who are likely to be successful in a science course.

The Education White Paper 3 further recommends that equitable admissions criteria be implemented. A test of science competencies can serve as a common yardstick against which to assess all applicants for preparedness. The different schools and colleges, from which the first year applicants evolved, followed their own syllabi and implemented their own criteria to promote their learners to the next academic level. This promotion, although acknowledged on the NQF, may or may not be a realistic or suitable yardstick for prediction of a learner's competency to succeed in the formal higher education phase.

There are a vast number of African (Black) students seeking admission to higher education (SA Survey 2000/01). Many South African researchers view an entry-level test, or combinations of entry-level tests, used in conjunction with other data, as the solution to the identification of preparedness in African students (Miller 1992, Rutherford & Watson 1990, Yeld & Haeck 1996, Zaaiman 1996).

Fourie and Naude - de Jager (1992) point out the importance of specifically testing the ability of science students to do physics. Fourie and Naude–de Jager (1992) found that students who underwent an academic selection process and were admitted on its outcome, still showed a 100% failure rate in physics. In the second year of implementation of the selection process the failure rate was still high at 67%. Although the selection process identified these students as prepared for higher education, it did not identify them as at-risk for physics. This finding clearly endorses the importance of a specialised science entry-level test.

According to Taylor (1992) and Huysamen (1997) psychometric tests, depending on their accuracy, have a role to play in identifying potential in disadvantaged students. Huysamen (1997) points out that the outcomes of the tests can be used to counsel students about courses best suited to their abilities.

Further motivation for the development of a science entry-level test is that the test will distinguish the prepared from the under-prepared and unprepared, but not disallow entry to those believed to be under-prepared, or for whom the matriculation results have proven to be very poor predictors of success. In addition, the Grade 12 results are not always available when students need to be selected for higher education (Calitz 1984, Miller 1992, Rutherford & Watson 1990, Yeld & Haeck 1997, Zaaiman 1996). In such instances, the Science Competency Test can serve as a substitute measure.

1.10 CONCLUSION

In this chapter, the significance of this research, as well as the value testing can have in identifying students who are prepared or are under-prepared but who could possibly succeed in higher education, were highlighted.

In the chapter that follows a review of the literature provides an overview of admission testing at tertiary academic institutions, both in South Africa and internationally.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The field of admission testing raises two contentious issues. The first is whether to test for preparedness by means of an entry-level test, or to test for potential to learn (Griesel 1992). The second issue is fairness of admission testing with specific reference to the use of content in entry-level tests. A premise on which the study is based is drawn from the discussion of these issues.

Under the heading of literature review, comparisons are drawn between existing entry-level tests in terms of their purposes, type of items used, number of items per test and breakdown.

2.2 PREDICTING SUCCESS IN HIGHER EDUCATION

Attempts at the prediction of academic success in higher education are not recent occurrences (Huysamen 1999). Institutions of higher learning have always admitted some students and refused entry to others, and the decision of who to admit was based mainly on the prognostication of success at higher learning.

It has become vital for South African institutions of higher learning to reconsider the entrance criteria on which their prediction is done. In the past, school performance (Matric/Grade 12 results) was used as the sole entrance criteria (Huysamen & Raubenheimer 1999). Recently, these criteria have proven ineffective in predicting academic success for the majority of the current student population (Botha & Cilliers 1999, van der Merwe 2000).

The factors that gave rise to the need to review entrance criteria are fourfold: the demand for admission places, the recommendation of White Paper 3, the scarcity of funds and the introduction of Outcomes-based Education Curriculum 2005.

Since the mid-1980's, institutions of higher leaning have opened their doors to all race groups. The number of students from disadvantaged communities has escalated exponentially and it is forecast that it will continue to grow (Badsha 1992, File 1992, Fourie and Naude-de Jager 1992).

According to the SA Survey (2000/01), between 1979 and 1999 the number of Grade 12 learners writing the Senior Certificate examinations increased by 500% and the Senior Certificate pass rate increased by 5%. Furthermore, according to the National Plan for Higher Education launched in March 2001, the participation in higher education will increase from 15% to 20% over a period of 10 – 15 years (SA Yearbook 2001/02). Badsha (1992) predicts that for the decade ending 2009 there will be a 291% increase in the number of African matriculated school leavers. According to File (1992) the number of African students passing with matriculation exemption is likely to increase in the next decade and beyond. It is further estimated that 81% of the Republic of South Africa will be African by 2010 which will mean that the student number ratio of African to White will reflect the demographics of South

Africa in higher education as well (Fourie & Naude-de Jager, 1992). The participation of Africans in higher education between 1993 and 1999 increased from 40% to 59% (SA Survey 2000/01). In 1999 the student ratio of African to White at technikons countrywide was 3:1 (SA Survey 2000/01).

When considering the large numbers of African students and the serious under-preparedness of the majority of them, the identification and selection of those with potential to succeed in higher education becomes crucial (Zaaiman et al 1998) and a 'great challenge' (Botha & Cilliers 1999:144).

This influx of learners highlighted four issues pertinent to tertiary institutions.

- The limited available resources. The number of applicants exceeds the number of available space at tertiary institutions.
- In view of the limited resources, all applicants cannot be admitted which in turn makes selection unavoidable.
- The Grade 12 results do not reflect the true potential of the disadvantaged learner (Huysamen 1999, Miller 1992).
- The majority of students from disadvantaged communities are under-prepared (Huysamen & Raubenheimer 1999).

The recommendations of the Education White Paper 3 that the access to students of colour be increased and by so doing to increase the ratio of African to White students, also demanded a reassessment of entrance criteria. The Education White Paper 3 also stipulates that an increase in the success rate of these students should complement the increase in intake. Given the general under-preparedness of the students of colour, one challenge arose immediately: alternative admissions requirements had to be devised since the Grade 12 results did not reflect the future academic performance of the under-prepared accurately, (Miller 1992, Rutherford & Watson 1990, Yeld & Haeck 1997, Zaaiman 1996) and educational intervention for the under-prepared had to be developed.

The scarcity of funds in a developing South Africa with its recent political changes into a new democracy and its repressed economy also impacts on admissions. Funds are needed to implement change and lack thereof means that the resolving of issues such as the limited resources and hence admission are retarded.

The introduction of Outcomes - Based Education Curriculum 2005 (OBE) has brought about total and revolutionary changes in evaluation and examination procedures in school curricula. Two full-scale examinations for the twelve year school period have replaced the regular class testing and three school examinations written by learners each year. In the new OBE Curriculum 2005, more class tests will occur and a larger percentage of a subject mark will be for individual and group assignments. As a result, institutions of higher learning in South Africa have a great concern that Grade 12 results will now, more than ever, not reflect the true preparedness of students for higher learning.

As explained above, admission criteria and or prediction of academic performance is an increasingly pressing issue to all institutions of higher learning today (Scott 1992). Currently, the alternative is whether to have admissions testing or not. Griesel (1992), Miller (1992), and Zaaiman (1996) argue that it would be unfair to have students from the disadvantaged communities compete for admission on an equal footing with the students from privileged schools. These researchers are against admissions testing.

On the other hand, entry-level tests used in conjunction with other data are viewed by Rutherford & Watson (1990) and Yeld & Haeck (1997) as the solution to the problem of identification of preparedness in students.

Irrespective of the admissions tool the institution decides on, prediction or selection is inevitable, warns File (1992). 'At the same time, the quest for reliable and valid instruments for the identification of such individuals (the disadvantaged) in a selection process has barely begun' (Huysamen & Raubenheimer 1999:171).

In the United States of America school performance together with the American College Testing (ACT) or the Scholastic Aptitude Test (SAT), both entry-level tests, are used in the

first stage of the admission procedure (van der Merwe 2000). The USA has entry-level tests for practically every course offered at higher education level (Sweetland & Keyser 1983). The tests measure a combination of knowledge, skills, understanding, application of knowledge, and whatever else constitutes the trait being measured. These tests cannot be transferred to the South African environment since we follow different curricula both at school and at higher education. Other countries that make use of school performance and entry-level testing include Sweden, Philippines and Indonesia (Huysamen 1997).

Previous research on the prediction of academic performance in science courses, particularly in chemistry and physics, have been conducted by various researchers over the years (Carter, LaRussa and Bodner 1987, Mitchell 1989, Ozsogomonyan & Loftus 1979, Pribyl & Bodner 1987, Rutherford & Watson 1990), as evidenced by the numerous science ability, achievement, placement and prediction tests for all the age groups available in America (Sweetland & Keyser 1983).

2.3 HISTORICAL BACKGROUND OF SOUTH AFRICAN EDUCATION

In the period prior to 1991, the South African education system reflected the distinct 'divide and rule' policies of its apartheid regime. There were four main education departments for the race groups African, Coloured, Indian and White. In all there were nineteen education departments (Bengu 1995).

During apartheid South African education was racially skewed:

- Each department followed its own curriculum and wrote its own examination papers. The standard ranged from most inferior for the African, inferior for the Coloured, better for the Indian and world class for the Whites (Portfolio on SA 1999/2000, Yeld & Haeck 1994).
- Learners of colour were discriminated against in terms of unequal opportunity to succeed in school, lack of school amenities and the unavailability of qualified teaching staff.

- The school days of learners of colour were disrupted regularly due to political upheavals. Sometimes months would pass before schooling could be resumed.
- An objective of apartheid education was to ensure that Africans remained labourers and Whites, with their superior education were primed to remain in control of the education and economy in the country. This objective was entrenched by the unequal educational provision for the different race groups by the apartheid regime.
- Another crippling factor in the education of learners of colour during this period was the ongoing economic struggle forced by their parents. In most cases, the socio-economic circumstances at home were not conducive to learning.
- Schooling was not compulsory for Africans which meant that the number of Africans who reached Grade 12 was alarmingly small compared with the number of Whites (Badsha 1992).
- The scenario for higher education during the apartheid period was much the same. Higher education in South Africa has a history of inequitable distribution of access (Mehl 1992). The disadvantaged were not granted equal opportunity to succeed at education (Woodbridge 1995). South African higher education is known for its disparities between educational provisions in terms of facilities and capacities for historically White and African institutions (Skuy et al 1996, Yeld & Haeck 1994).
- It is a sad fact that apartheid education failed to serve the needs of the economy and to supply skilled employees to labour markets. Furthermore, it failed to educate and uplift the communities and was unresponsive to the needs of society (Education White Paper 3, Aug.1997, Khotseng 1992, Manamela 1997). In 1999, 11.8% of the adult population in South Africa had no education, 25.6% had primary education and only 51.1% had secondary education (SA Survey 2000/01).

Since 1991 major political transformation has occurred in the country. A democracy replaced the apartheid system in 1994. A single national education ministry responsible for policy, standards, planning funding allocations and management of education replaced the old racially-separated departments. Regional departments are located in each province and learners in each province write provincial examination papers in most subjects. However, in

2001 five subjects, namely accounting, biology, English, mathematics and science, were written nationally to enforce uniformity of standards (Johns 2001, SA Survey 2000/01).

Despite these welcome and much-needed changes, the aftermath of decades of oppression will be prevalent for many years to come (Skuy et al 1996).

As a consequence of the aforementioned reasons, the poor academic performance of Africans is, to a large extent, understandable. Their progress is further thwarted by the fact that English is the medium of instruction at many tertiary institutions, whilst for many learners, English is not the vernacular.

Since these institutions of higher learning were opened to all races, the student body has become increasingly representative of the diverse cultural, socio-economical and educational backgrounds of the South African population (Koch, Foxcroft and Watson 2001). The well-prepared White student population is now the minority and the majority is from the disadvantaged communities (SA Survey 2000/01).

Universities and technikons are compelled to transform and assume a democratic, central and significant character (Education White Paper 3, August 1997). The institutions should serve the communities in which they exist and function within the new democratic South Africa. These institutions were noted for their distant, remote, elitist and marginal features, but are now compelled to become more accessible and useful to the majority of the population and to assume the customs and ethos of the South African people (Khotseng 1992, Manamela 1997).

2.4 FUTURE DEVELOPMENTS IN HIGHER EDUCATION

In the light of our new political era, all forms of state-governed operations have been forced to transform to serve the new democracy. Any structure that still perpetuates the apartheid ideology or continues to serve its aims has to change or be removed and be replaced by ones, which support the new democracy (Education White Paper 3, August 1997).

Education fulfills a central and pivotal role in any country. It is the medium through which the social, cultural, educational and economic amelioration of its people and the growth of its economy can be best achieved. Hence, a review of the education system of the country became a priority.

The Education White Paper 3 of August 1997 highlighted the following issues that required attention:

- The South African school system did not prepare the majority of its learners for higher education.
- The previous education system rendered the majority of the people of South Africa illiterate.
- Institutions of higher learning served an elitist minority.

- Institutions of higher learning remained irrelevant and inconsequential to the communities around them.
- Higher education failed to feed the economy with much needed labour skills and curtailed economic growth.
- Institutions of higher learning exuded an atmosphere foreign to the ethos of South Africa and its people.

In short, these institutions have become unsuitable in the face of a new democracy, which has as its aim service to, equal participation and prosperity for all. Their status had to be revamped to render them useful contributors once more.

The Education White Paper 3 of August 1997 explains the role that higher education should assume within the new democracy. The following four cornerstones of higher education and for the transformation process are mentioned:

- Vision for higher education.
- Purposes of higher education.
- Issues that need to be transformed.

- Guidelines for the transformation process.

Each of these four is elaborated on next.

2.4.1 Vision for higher education

The Education White Paper 3 visualises a system that concentrates on open access, the generation of knowledge and the economy of the country.

It stresses the importance of multiple access routes into higher learning and not only via a Grade 12 certificate, but through recognized prior learning. In striving to generate and create new knowledge, the higher education system should focus on solving problematic issues and needs within the communities, nationally and internationally.

The Education White Paper 3 visualises a higher education system which is in line with both the economic demands of a developing country and international trends, and which will generate the necessary employment skills of a burgeoning economy.

2.4.2 The purposes of higher education

The ultimate role of higher education is to underwrite the democracy, to eradicate past inequalities, to uplift the people of the country socially and educationally, to ensure a growing economy and to create new knowledge. Higher education should be aimed at meeting the moral, political and economic needs of the new South Africa. This can be attained by:

- Meeting the learning needs and aspirations of individuals.
- Addressing the developmental needs of society and by providing the labour market with the necessary competencies to ensure economic growth.
- Generating new knowledge through research, learning and teaching.

2.4.3 Issues to be addressed

The Education White Paper 3 points out the three issues of access into higher education, the lack of science and technology graduates and needs of the communities and of Africa in the broader context that need to be transformed.

- Access: Institutions should alter their access policies to support an equal participation rate as well as equal opportunity to succeed for all.
- The dearth of science and technology graduates in the country should be addressed and replenished.
- There is inadequate focus on the needs of communities and of the country as a whole as well as globally.

The Education White Paper 3 states that transformation of the above issues will lead to a total change in the nature, structure and character of all institutions.

2.4.4 The principles guiding the transformation process

The Education White Paper 3 mentions three principles that should to guide the transformation process.

The first principle is 'equity and redress' which means that impartial and fair opportunity is awarded to all to enter and succeed at higher education. The transformation should be aimed at redressing past inequalities and all obstacles that will impede fair opportunity and redress should be removed.

The second principle is the maintenance of educational quality. During the transformation academic excellence should not to be compromised, but instead strived for.

The third principle is institutional autonomy with regards to admissions policies. The Education White Paper 3 does not dictate an admissions policy to any institution, but instead, stipulates that what is adopted should underwrite, and not oppose, the democracy and purposes of higher education.

2.5 EQUITY, GROWTH AND REDRESS

The ultimate aim of equity, as the fair opportunity for all to participate and succeed at higher education with special emphasis on those who were previously denied entry, is to build a student body representative of the demographics of the country.

The aim of redress is to remedy past imbalances such as unequal access, unequal opportunity to succeed, denied entry to higher learning, etc. by looking at alternative methods of identifying potential in the disadvantaged student, especially since entry refusal had previously been based on poor school performance.

Increased access can be achieved by making the following changes:

- Diversifying the curriculum to better suit the needs and interests of a more varied student body. Career-orientated courses to feed the demands of the labour market can be offered (Khotseng 1992, Manamela 1997). The education offered should be based on the collective creation of the kind of knowledge that can transform socio-economic conditions, professional experience and cultural life.
- Offering of full-time, part-time, distance learning and resource-based learning facilities at tertiary institutions.
- Introduction of more flexible admissions procedures. Admission policies should recognise prior learning experiences and offer a range of alternative routes to higher education. Admission policies should promote entry of those who are able to benefit from higher education, despite not meeting entry requirements or an inability to attend full-time programmes (Khotseng 1992, Mehl 1992).
- Promotion of access into higher learning of the disadvantaged by cultivating their capabilities and resources through training and education so that they could participate in, contribute to and enjoy the fruits of social upliftment and economic development of the country. Due to apartheid, the country has masses of wasted resources and potential in the previously disadvantaged (Jordaan 1995).

- Granting preferential admission to applicants who apply for courses relevant to the needs of the job market and the country (Khotseng 1992, Mehl 1992).
- Encouragement of research that leans towards solving the needs and problems of communities and the country. This will close the gap between the institutions of higher learning and the communities around them and make them more meaningful and relevant.
- Implementation of a single qualifications framework that is in line with the National Qualifications Framework. This will improve mobility within the system.
- Establishing admission policies that are studied and coherent and that are implemented nationally Mehl (1992). Such admission policies will promote accountability for the maintenance of academic excellence by all involved in the education process, namely the admission officer, the lecturers, the faculty where the student studies, etc.

2.6 EQUITY versus EXCELLENCE

The debate between equity versus excellence is also known as equality in education versus quality in education, democracy versus meritocracy and egalitarianism versus elitism (Steyn 1995). Although an age-old debate, educators and academics here have taken up the debate and are weighing its arguments within a South African context.

The debate rose in prominence due to the escalation in numbers of under-prepared students from the disadvantaged schools at institutions of higher learning. Recommendations from the Education White Paper 3 to institutions of higher learning to increase their intake of students from disadvantaged schools and to ensure that the output-rate of these students also increased, enhanced the urgency of the debate. These institutions are, at the same time, also urged to maintain quality in the education offered.

The concern of those participating in the debate is that less restrictive access could lead to a drop in academic quality. In the past academic quality was attained and easily retained due to the selectivity of the system: admit only those who are adequately prepared for higher education and be certain of maintaining academic excellence. It is feared that the admission

of greater numbers under-prepared students will force the institution to lower its standards and the quality of education offered.

The South African debate has racial overtones (Steyn 1995). Africans are of the opinion that Whites are using the equity versus excellence debate to maintain a stronghold over education (Steyn 1995), hence the apparent concern with standards and reluctance to relax entrance criteria. According to Steyn (1995), Africans are demanding equality and redress in education and argue that less restrictive access will not necessarily lead to a drop in standards.

Despite the racial innuendos, it is important that the strategy decided upon be of benefit to the majority of the people in the country. Ultimately, two questions need to be answered. The first one is whether the two concepts of equity and excellence are mutually exclusive or whether it is possible to have both simultaneously. The second question is how to maintain excellence in education.

Jordaan (1995) and Steyn (1995) are of the opinion that equity and excellence are essentials of relevant education and together they lend credibility to an educational system. The implication being that any institution should strive for both simultaneously and that one without the other will impact negatively on the institution and the education on offer.

Claassen (1993) offers two ways of achieving equity in education. The first is to make available equal funding for all learners irrespective of race. This will give rise to equality of opportunity for all. However, it is noted that this is a superficial change that does not promise academic success. The second suggestion is to aim for equality of result. This entails a profound, intrinsic transformation that guarantees educational success at the same rate that the advantaged are performing. It means that the entire education system, from its curricula to the under-qualified teachers to equal educational provisions in terms of amenities and resources to educational intervention etc., will be restructured in such a way as to allow each learner irrespective of race to develop his/her full academic ability. It involves more than mere replacing of discriminatory practices, but reparation by society as a whole.

Huysamen (1997) offers the 'fitness for purpose' or 'value-added' concept. In this instance a student who does not meet entry requirements is admitted and then assisted to acquire knowledge and skill. The term 'fitness for purpose' is the ability to which different sectors in the system meet different purposes. The term quality is replaced by the term 'fitness for purpose'.

Woodbridge (1995) uses the Farrell-model to explain how equity that will lead to quality in education can be achieved. The Farrell-model proposes four types of equality in a collective system that yields quality in education.

Equality of access - the system should open access to all and provide different points of access; parents have the right to choose the form of education for their children, also with regards to religion and language.

Equality of survival - equal advantages; the State should deploy its resources so that they are used to provide the same quality of learning opportunities for all to enable them to survive the system.

Equality of output – equal achievement. The State should improve the quality of its educational services, which in turn will improve the performance of learners.

Equality of outcome - the learning needs and aspirations of the individual should come first; the system should offer a diversified curriculum choice to accommodate a broad and varied learner population, especially after the compulsory school phase.

School systems wherein all four equalities are addressed simultaneously are assured of equity as well as quality. Collectively, the four equalities result in quality in education.

Another dimension in the South African debate is the issue of redress. What is its importance in relation to equity and quality in education? Should it be granted priority over the other two and be addressed first in the transformation process? How should these three issues be addressed in the transformation process? Steyn (1995) cautions that redress in education is presently more important in South Africa than quality in education, whilst Jordaan (1995:54)

suggests that redress ‘should be aimed at the demonstration of excellence in the presence of equity for the benefit of the disadvantaged in the university educational context’.

A further concern is how to maintain academic excellence? The two possible solutions are to extend the number of years of study and to offer educational intervention. In the former solution, an existing three-year course is offered over an extended period of four to five years. This extension was implemented at the University of the North (Malatji 1992). The latter solution is to lower entrance standards and then offer academic support programmes in order to meet and maintain exit standards (Jordaan 1995).

Excellence in education presupposes availability of resources and accountability. File (1992) points out the interdependence of the number of students, available resources and the quality of the education when urging that a growth in numbers, should be complemented with a growth in resources, if one is to maintain quality in education.

Mehl (1992) holds the opinion that the crucial importance of accountability in education cannot be over-emphasised and structures to assess the effectiveness of teaching, learning and research in higher education at all levels should be put in place. Mehl states that presently there is no tradition of accountability in South Africa. In order to assess each individual's effectiveness in the system, means of assessing them should be effected. Once each individual's effectiveness can be assessed, the overall effectiveness and quality of the system as a whole can be judged.

The Education White Paper 3 (August 1997) gives insufficient guidelines as to what the multiple purposes of higher education are going to be. There is as yet no agreement amongst the different campuses as to what the different programmes are going to be. The definitions of what quality in the diverse curriculum should be have not been formulated and neither have the means for its assessment been determined.

Each institution is responsible for individual quality assurance (Education White Paper 3, August 1997), although a national authority (the Higher Education Qualifications Council) responsible for national quality promotion and assurance in higher education will be

established. It is possible to draw from overseas experience where the measurement of quality in a diverse education system is related to the diversity of purposes of higher education (File 1992). In the South African context much has still to be finalised with regard to admissions and selection policies as well as issues pertaining to the curriculum.

2.7 PROBLEMS ASSOCIATED WITH TESTING

In several countries strong disapproval of admissions testing have been raised (Sax 1989). Huysamen (1997) lists Angoff's criticisms against testing. Angoff states that tests:

- Do not predict significantly.
- Predict the wrong things.
- Fail to measure the fundamental traits of character and ability. For example, tests do not measure love and creativity and motivation.
- Are not precise enough.
- Are susceptible to coaching - prior exposure to tests invalidates the test for its intended purpose; test scores of test takers who are familiar and of those who see the test for the first time, cannot be compared.
- Are culturally biased - this is one of the most serious allegations against testing because the backgrounds in language, motivation, history of political depression and socio-economic factors are not taken into consideration.
- Operate behind a veil of secrecy.

Sax (1989) has the following additional criticisms:

- Tests represent an invasion of privacy when they require you to reveal information of a personal nature.
- Tests measure what is determined by curricula.

Huysamen (1997), Miller (1992), Yeld & Haeck (1997) and Zaaiman's (1996) main concerns are that admission testing could be harmful to efforts to increase access for the

disadvantaged groups because it fails to predict potential and that it perpetuates the educational inequalities of the apartheid system because of its reliance on content.

2.7.1 Ethical testing practices

Sax (1989) states that testing presumes an ethical and responsible attitude on the part of the testing personnel and teachers, and a desire to cooperate on the part of students. As such, mutual trust, respect and understanding mark the relationship and form the basis of any testing procedure. According to Sax (1989) a code of ethics exists for the testing fraternity and define the accountability and conduct towards the public. It safeguards the public against the misuse of tests or personal data by testing personnel as it outlines those acts that the testing profession should avoid in fulfilling their obligation to the public.

In 1988 the Joint Committee on Testing Practices which was initiated by the American Educational Research Association, the American Psychological Association and the National Council on Measurement in Education have published the principles of ethics relevant to testing in (Code of Fair Testing Practices in Education 1988). These principles are outlined below.

2.7.1.1 Principles of ethics

The principles are aimed at both the test developer and test user.

- Confidentiality - as the student's welfare is of greatest concern, any information regarding the test results is confidential and is communicated between the test taker and test user and/or the parents only.
- Test Security - tests are professional instruments and should only be open to those with the technical competence to use them properly.
- Test Interpretation - test developers should help users to interpret scores accurately. The test developer should explain the limitations of the test and warn the user against misuse and misinterpretations of the test. Test scores and materials should be made available only to those who are qualified to use them.

- Test Publication - standardised tests should provide a manual or technical handbook describing how and by whom the test can be used most effectively. This information is necessary to allow the user to select appropriate tests.
- Striving for fairness - test developers should strive to make tests that are, as far as possible, fair for test takers of different races, gender, ethnic backgrounds, or handicapped conditions.

2.7.2 Summary

It is clear that all methods of predicting success have their limitations. It is therefore advisable to evaluate any selection method against the effectiveness of other available systems, or against Angoff's inventory of criticisms.

Those who attempt admission testing, should be aware of its limitations and should be clear about the trait or attribute they wish to assess and the extent to which it can be measured directly (Scott 1992). By being constantly well aware of the limitations, guided by the principles of ethics and all the criticisms raised, it is possible to achieve useful results. Despite all the limitations of testing, it remains the swiftest and easiest method of appraising a large number of applicants.

The main criticisms against admissions testing are the predictive power and cultural bias of the tests. Huysamen (1997) reports on these issues that bias in any predictor may be removed statistically. This means that where students had different quality schooling that psychometric tests can still be used as a component of admissions testing. On the issue of predictive power, he states further that it can be improved by using the test in conjunction with other admissions procedures.

2.8 EXPERIENCE IN TESTING

2.8.1 Introduction

The earliest selection procedures did not involve any real testing. As Anastasi (1982) and Huysamen (1997) report, personal characteristics such as patriotism, physical attributes, school performance, family connections, affluence and school attended could previously ensure your selection.

Huysamen (1997) reports that the requirements for admission to institutions of higher learning vary in different countries and do not remain the same over the years. Socio-political changes, the advance of science and technology and the emphasis placed on them in developing countries, together with the increase in demand for admission at institutions of higher learning, are factors that have contributed to the inception of more sophisticated and scientific methods of identifying academic potential in students.

2.8.2 Experience overseas

The selection of students for higher learning occurs worldwide and has been going on for many decades. Admissions testing in China dates back to 1966, under the Communist Party, when students were selected mainly on the basis of revolutionary ardour and their desire to serve the nation (Huysamen 1997). China reverted to entrance examinations eleven years later when it was trailing the world in science and technology.

In the United States of America, the Scholastic Aptitude Test (SAT) was introduced in 1926 (Anastasi 1982). A common yardstick against which students from elite and public schools could be measured for admission to institutions of higher learning was needed. The SAT was used to measure readiness for higher education. The aim was to measure skills and abilities that were not inhibited by poor teaching practices and did not rely heavily on school syllabi. The SAT also proved useful in measuring preparedness in war veterans with their diverse educational experiences after World War II (Anastasi 1982, Thorndike & Hagen 1969).

In 1959, the American College Testing (ACT) Program, a competing test battery was introduced. It differed from the SAT in that it measured academic achievement in the areas of English, mathematics, reading and reasoning. Like SAT it was not based directly on school curricula (Anastasi 1982, Thorndike & Hagen 1969).

2.8.3 Current testing procedures

United States of America

The majority of students are required to write standardised achievement tests when applying for admission to higher education (Anastasi1982, Rutherford & Watson, 1990, Thorndike & Hagen 1969). Students are admitted on the basis of school performance and the standardised achievement test scores: SAT and ACT scores. Institutions implement the multi-stage selection approach. The first stage of selection is based on SAT and ACT scores. It was found that the minority groups are usually under-represented after the first stage. A second stage was introduced to increase their representation. This is achieved by looking at variables such as geographic location, age, former experience, etc. (Suransky 1992, van der Merwe 2000).

Walsh & Betz (1985) report that colleges and universities prescribe their own minimum score on these standardised tests as entrance prerequisite. Special and selective institutions require their applicants to write additional entrance tests that measure specific competencies related to the specific field of study.

United Kingdom

In the United Kingdom students write 'O' and 'A' level examinations. On the basis of above average 'A' level scores and a prescribed combination of subjects, students gain entry to higher education (Rutherford & Watson 1990).

Sweden

The Swedish Scholastic Test (SweSAT) was developed for much the same reason as the SAT in the United States of America. Huysamen (1997) states that like the SAT the SweSAT was used as a common yardstick to compare preparedness between applicants of 25 years or older with four years' work experience and individuals straight from school.

Israel

In Israel, the Bagrut was used as a requirement for admission to universities (Huysamen 1997). The Bagrut is similar to the South African matriculation exemption. With an increased demand for higher education in Israel in the sixties and seventies an admissions test was implemented to complement the Bagrut.

Huysamen (1997) adds that a scholastic aptitude test for selection purposes appeared later and in 1981 the Institute for Testing and Evaluation introduced the Psychometric Entrance Test (PET). Today, each Israeli university has its own admissions policy, but their admissions decisions are based on both the Bagrut and the PET scores.

Philippines

Initially, only school results were used for admissions, but as the demand for places increased, an admissions test, The College Admissions Test, was used in conjunction with school results (Huysamen 1997). This increased the significance of their predictions and their success rate increased from 70% to 90% (Huysamen 1997).

In summary, the reason for introducing admissions testing in the countries mentioned was to identify preparedness in applicants from different school and teaching practices and with diverse working experiences. Another reason was an increased demand for higher education, which created a demand for places at institutions of higher learning.

Most of the admissions tests were, as far as possible, not based on school curricula, but instead concentrated on the measurement of skills and abilities. In most of the countries the entry-level tests were used in conjunction with school performance.

2.8.4 Testing experience in the Republic of South Africa

For many decades the sole requirement for admission to university was the matriculation exemption. Technikons and colleges required a Grade 12 pass, whilst certain courses dictated prerequisite subjects, such as mathematics for science courses.

These entry requirements worked extremely well whilst the universities and technikons were predominantly White (Huysamen 1999).

Since the middle 1980's institutions of higher learning were opened to all races. Immediately the homogeneity of the student population changed. It was soon discovered that Grade 12 results did not predict the academic performance of the ex-DET learners. (Calitz 1984, Miller 1992, Rutherford & Watson 1990, Yeld & Haeck 1997, Zaaiman 1996).

Institutions of higher learning in South Africa are proactively and progressively looking for adequate solutions for the identification and selection of disadvantaged students with potential to succeed in higher education (Zaaiman et al 1998). Presently, four approaches are being examined. The first one is admissions testing (Rutherford & Watson 1990, Zaaiman 1996), the second is the multi-stage admissions approach (Botha 2000, Botha & Cilliers 1999, Rutherford 1992, Suransky 1992, van der Merwe 2000), the third is the Teach-Test-Teach (TTT) method by Griesel (1992) and the fourth is placement testing (Huddle and Green and White 1999, Yeld & Haeck 1994).

2.9 THEORETICAL FRAMEWORK

The issues of the use of content in an entry-level test, what to test for in an entry-level test and fairness in testing as they are applied in this, and other related research, are explained. This section concludes with a summary of the main points on which the theoretical framework of this research is based.

2.9.1 The use of content in entry-level tests

When establishing a test that will be used to predict future academic performance, a decision of whether or not to include subject matter (content) has to be made.

There are two schools of thought pertaining to the use of content in entry-level tests. The one school of thought is that entry-level tests should be content-free (Griesel 1992,

Huysamen 1997, Miller 1992, Walsh & Betz 1985), whilst the other school of thought is that content can be included (Altink 1987, Rutherford 1992, Sweetland & Keyser 1983).

Within the group that supports content-free tests there are two viewpoints. These stem from a difference of opinion about the meaning of aptitude (hereafter referred to as ability) and its influence on academic performance. According to Walsh & Betz (1985) an individual is born with an ability to, for example, excel in sport. Since this ability is inherent, he/she will do well in sport, whether he/she gains knowledge and training before embarking on a sporting career. The implication is that ability exists without prior schooling and training. Similarly, the ability to be successful in a study field is independent of schooling and training and can therefore be determined by tests that are free of subject-related content.

The second viewpoint is that ability is affected by prior learning experiences (Altink 1987, Brown 1983, Griesel 1992, Huysamen 1997, Miller 1992, Rutherford 1992, Yeld & Haeck 1997). The aforementioned share the opinion that ability is partly affected by the innate characteristics and partly by life experiences. According to this group, ability can be improved by good schooling, training and educational intervention. This group is also in favour of content-free tests, although for entirely different reasons. They are further of the opinion that since ability can be enhanced by education and training, the use of subject-related content in entry-level tests that are administered to learners from differential school backgrounds, will yield differential results. It is felt that learners who had poor schooling are weak in, or lack, the necessary achievement skills needed to do well in these tests. In contrast, learners who enjoyed a better schooling will fare better in these tests. Any conclusions as to the academic potential, or future academic performance of the learners with a poor schooling, drawn from such test scores will be invalid because of unequal educational opportunity.

Two subgroups emerge from this second opinion. The one subgroup (Altink 1987, Rutherford & Watson 1990) sees the solution in the use of the least amount of content and content-free tests. The other subgroup makes use of the TTT method to select prospective students (Griesel 1992).

The TTT method offers an alternative to entrance testing. It is an educational intervention programme that aims to assess the learner's ability to change or adapt within the educational intervention opportunity offered. The learner's learning potential is assessed. With the TTT programme the learner's learning potential is nurtured over a two-week period, and the extent of the growth is assessed afterwards. The prediction of future academic performance is then based on the extent to which the learner shows capacity to change. This method contrasts the assessment of manifest academic ability of learners, on the basis of which a prediction of future academic performance is made.

The second school of thought supports the use of content and do so to increase the predictive power of their test batteries (Altink 1987, Rutherford 1992). The majority of the American entry-level tests are achievement tests, i.e. make use of content (Sweetland & Keyser 1983).

2.9.1.1 Literature in support of content tests

The syllabi of academic support or educational intervention programmes at institutions of higher learning entail the teaching of fundamental concepts and skills (Volmink 1987). In these programmes the understanding of the concepts and skills is emphasised as they are regarded as important tools in the improvement of the academic success rate of students.

Mitchell (1989), Russell (1994) and Rutherford & Watson (1990) report that lecturers assume certain prior knowledge and skills of their first year students. To test for these assumed knowledge and skills is therefore not without grounds, but could be useful in determining what prospective students know. Lecturers build on what they assume the student already knows. A student, who lacks the assumed knowledge base, could flounder in the first year class and fail. An entry-level test should therefore test for the assumed knowledge and skills so that one can gauge the knowledge base of prospective first year students and their chances of grasping subsequent knowledge.

Altink (1987) and Gronlund (1985) state that achievement tests which cover specific subject-related content areas are better able to predict future academic performance in that specific

area, than are content-free tests. They both share the opinion that past academic achievement is always a better predictor of future academic achievement within the same field.

Mitchell (1989) reports that although high school teachers and lecturers have different ideas about what knowledge and skills are needed to pass the first year of chemistry, first year applicants can be expected to know only what was taught in school. A test that assesses this knowledge and skills is therefore relevant.

In the USA there are numerous entry-level tests that contain content and skills and which are reportedly significant predictors of success (Sweetland & Keyser 1983).

In South Africa, Rutherford (1992) found that her test battery predicted more significantly after adding a basic science test (of content) to a previous test battery (of 1990).

The Texas Academic Skills Program (TASP) (1998) also makes use of content. This instructional programme aims at preparing students for higher education. The programme includes preparation programmes, testing for preparedness and educational support and advisory services. The TASP tests for preparedness according to a list of validated skills and content. The programme bases its educational support and advisory services on the results of the skills test.

2.9.1.2 Literature that does not support the use of content

The main example of content-free testing used in South Africa is the TTT method used by Griesel (1992). This approach uses learning tasks and course content unknown to students. The students are taught new content and assessment of who best responds to the intervention is done. The development of the mental processes within the two weeks of the educational intervention period is assessed.

2.9.2 What to test for in entry-level tests

The decision of what to test for is dependent upon how clearly the trait can be defined, whether the trait has been developed within the test taker (as presupposed by psychometric testing practices), and how well the trait can be assessed in a paper-and pencil test (Cronbach 1970).

The TASP (1998) tests for preparedness, Griesel (1992) tests for learning potential and most American entry-level tests assess achievement or manifest ability.

In the opinions of Miller (1992) and Griesel (1992) one cannot test for manifest academic ability or potential because it does not exist or was not fully developed in ex-DET learners and would also assume prior learning. These two researchers as well as Yeld & Haeck (1997) support the testing of potential to learn, also referred to as the learner's ability to respond to educational intervention or potential academic ability or learning potential.

According to Thorndike & Hagen, 'whether our interests center on outcomes of past learning or potential for the future, all we can test is present performance' (1969:293).

2.9.3 Fairness in testing procedure

Fairness in testing, also termed bias in testing encompasses all the stages of test development, the administration thereof, the scoring, the interpretation of test scores and the uses of the test scores.

A test item is considered fair when those who know the content of the item or have the skill tested by the item respond correctly and those who do not know the content or do not have the skill respond incorrectly. It is considered unfair when those who know the content or have the skill respond incorrectly, and those who do not know the content or do not have the skill, respond correctly.

Fairness in testing takes into account the influence of factors not relevant to the purpose of testing on test scores. These factors could include school background, religious inclinations, socio-economic background (items that might offend a certain group of test takers and special aspects of the group's background), content used in the items (language problems and the use of content in items which will create an advantage due to instructional and educational backgrounds), handicaps, race, gender, types of items used (some groups do better in certain item types) and scoring should be done as objectively as possible ((Gronlund 1968, Sax 1989, Thorndike 1982). These factors can result in an item, or the test as a whole being easy or difficult for a particular group, which in turn can result in differences in terms of average test scores and success rates (Gronlund 1968, Sax 1989, Thorndike 1982).

Fairness also involves the application of tests (Gronlund 1968, Sax 1989). According to these authors a test is biased when its use leads to different social and vocational consequences for different groups. For example a larger proportion of advantaged students being placed in jobs or labeled more intelligent. The test will be fairer if its score is not the sole criterion of selection. The correct interpretation of test scores, what they mean and do not mean, also perpetuates the practice of fairness in testing.

However, it is difficult, if not impossible, to set up an entirely unbiased test (Gronlund 1968). Since all human traits are developed through experience, persons whose backgrounds differ widely, inevitably react differently to the items and tasks in any given test (Tyler 1971).

As mentioned before, the use of content in entry-level tests is considered unfair testing practice when test takers are from unequal school systems. South African campuses that use content tests, implement the following measures to equalise differences in test scores for the advantaged and disadvantaged groups:

van der Merwe (2000) reports that the University of Stellenbosch has a two-tier selection and admission approach. In the first tier, the Grade 12 results are used as the norm for admission and selection (the Grade 12 results remain a significant predictor for the advantaged group). In the second tier, the disadvantaged students with poor Grade 12 results write Access Tests.

The Access Tests test subject-related skills and content and allow these students a second chance to be admitted.

Rutherford (1992), of the University of the Witwatersrand (Wits), also implements a two-tier approach for the admission to a Chemistry I course. In the first stage, admission to the mainstream Chemistry I course requires a 60% average in Grade 12 results. The second stage requires a Grade 12 exemption and a C-symbol on the Standard Grade for mathematics. In the second stage, students are given selection tests (content tests) to complete. On the basis of test scores students are referred to lower level Chemistry courses and a four-year degree course. Reportedly, this approach has yielded better results than previously used selection criteria (Huddle,Green and White 1999).

In the USA selection also occurs via a multi-stage process (van der Merwe 2000). In their first stage school results and the SAT or ACT scores are considered. In stage two the geographic location, age of the student, former experience, special awards, physical handicaps, family ties to alumni and the eligibility for sport scholarships are considered. The aim of the second stage is to increase the representation of the disadvantaged (van der Merwe 2000).

2.9.4 The dilemma of fairness versus predictive value of entry-level tests

Any test developer who intends developing a test to predict future performance designs the test instrument to have high predictive value. At the same time, the aim is also to grant each test taker regardless of race, gender or social class an equal chance to do well in the test.

The question is whether it is possible to develop a test instrument that is both fair to all and has high predictive value, especially when the test takers are from different and inequitable school backgrounds. If the answer to this question is no, the developer has to decide which characteristic is the more important.

Gronlund (1985) acknowledges that an achievement test is the best predictor of future academic success in the same field because a knowledge base on which to build new knowledge is necessary. The use of content in achievement tests renders their use unfair

practice towards the disadvantaged groups. The disadvantaged groups lack the necessary knowledge and skills to perform well in such tests.

Content-free tests measure traits such as spatial ability, logic and are without the reliance on formal subject content. As such, they are regarded as more fair because performance does not rely heavily on prior learning (Miller 1992). The downside of such tests is that they have lower predictive value (Brown 1983, Gronlund 1985).

The dilemma is obvious and the following may assist in finding a compromise. Because it is impossible to draw up an entirely content-free test where items do not rely on prior knowledge, the option is to use as little content as possible (Yeld & Haeck 1997).

Altink (1987) says that aptitude lies halfway between intellectual ability (inborn native potential) and achievement (subject specific knowledge, learning experience, content), which implies that a predictive test should be halfway between an achievement test and a content-free ability test (IQ test). Altink suggests a test that is minimally dependent on concrete knowledge and which tests insight, comprehension and problem-solving, which are all less dependent on prior learning, as the solution.

A test that makes use of only the necessary skills and knowledge that will help students to succeed in their first year, is viewed as an acceptable compromise.

2.9.5 Summary

This research considers the use of content as imperative. The notion that one can admit students who have no prior knowledge of the course and only on the basis of a content-free aptitude test is perilous (Walsh & Betz 1985). It is more plausible that an individual, who is already knowledgeable about a particular course, is able to benefit better from advanced course work.

This research will focus on the essential and relevant science skills and physical science content of the Grade 11 and Grade 12 syllabi, as identified by the researcher as contributing to academic performance in the first year. In doing so, it is hoped to exclude unnecessary

content. The use of content will be kept to the minimum further by using general everyday situations instead of subject-specific examples whenever possible.

Taking into account the approach of psychometric testing that one can only assess something if it already exists within the test taker, this research will test for preparedness in terms of the skills and knowledge a prospective student should have when he/she enters the first year of study.

This research will, due to the constraints of resources and time, explore the equalisation of expected differential test scores amongst the two groups by offering either advisory services, counseling, statistically compensated test scores or differential cut-off points or bonus points for the disadvantaged group (Gronlund 1968). Huysamen (1997) supports statistically compensated test scores to counter the effects of disadvantage. Jordaan (1995) supports academic support for the disadvantaged when she advises that it is better to lower entry requirements and offer academic support programmes in order to maintain quality in education.

The TTT method is seemingly a much better approach when one considers the fairness of testing (it makes use of content unknown to the students), but definitely more laborious, time-consuming (it is a two-week programme), needs more manpower to carry out and is expensive. A second drawback of the TTT method, is that lecturers remain uninformed about what the student does or does not know.

Regarding the dilemma of fairness versus predictive value of entry-level tests, the main issue is that any institution wants to admit the prepared student and after that the student who stands a reasonable chance to succeed if given the appropriate support. To achieve that a test instrument which will identify the prepared and under-prepared significantly is needed. The researcher believes that a test of science competencies is able to do that.

2.10 LITERATURE REVIEW

In the USA there are several tests that claim to predict academic performance in chemistry and physics (Sweetland & Keyser 1983). In South Africa, entry-level tests are fairly new. Of the existing ones, some still undergo refinement each year (Botha 2000, Rutherford 1992).

2.10.1 Factors that predict success in Science

Altink (1987), Zaaiman (1996) and Rutherford & Watson (1990) have looked at Piagetian formal reasoning ability, spatial ability, Mathematics and English proficiency as factors relevant to academic success in the sciences. In order to improve the predictive power of their test battery, Rutherford (1992) added a test of basic science knowledge.

The University of Stellenbosch developed six Access Tests namely Afrikaans, English, mathematics, thinking skills, numeracy and a physical science test (Botha 2000). The Access Tests measure subject-related skills and content. Students do not write all six tests. Depending on the course applied for, the student writes a selection of the tests. For prospective science students the mathematics and physical science tests carry more weight than the languages.

At Wits, the Chemistry Faculty developed a diagnostic chemistry test that assesses knowledge, understanding and problem-solving skills of prospective chemistry students (Huddle et al 1999).

van Eeden et al (2001) conducted a battery of tests at the M.L. Sultan Technikon as part of admissions testing. The test battery consisted of the General Scholastic Aptitude Test Senior, the Senior Aptitude Test, the Sixteen Personality Factor Questionnaire (South African 1992 version) and the Learning Potential Computerised Adaptive Test.

In the USA most tests used for admissions are achievement (content) tests. Mention is made of a few only: the Achievement Test: Sciences-Chemistry, Achievement Test: Sciences-Physics and the Toledo Chemistry Placement Examination measure high school knowledge of chemistry and physics and the skills in comprehension, application, analysis, synthesis and evaluation that have been acquired for using that knowledge (Sweetland & Keyser 1983). The Toledo Chemistry Test of 1981 measures general and specific chemistry knowledge.

Walsh & Betz (1985) report that prospective students for special courses such as Dentistry, Law and Medical School are required to write test batteries that contain similar tests to the SAT, (verbal and quantitative tests) as well as additional achievement tests relevant to the specialty field. Examples of such tests are the MCAT (The New Medical College Admission Test) for Medical School, LSAT (Law School Admission Test) for Law and DATP (Dental Admission Testing Program) for Dentistry. The MCAT contains four sections of which two are based on science knowledge and problem-solving.

2.10.1.1 Summary

From the sources listed, the factors that contribute to academic performance in the sciences are Piagetian formal reasoning ability, spatial ability, mathematics, proficiency in the language of instruction, thinking skills and content tests. The content tests measure science specific knowledge and skills, i.e. understanding, problem-solving, skills in comprehension, application, analysis, synthesis and evaluation. It should be noted that more than one predictor variable was used in any screening procedure mentioned above. In the science field it can be said that most tests used contain content (Altink 1987, Rutherford 1992, Sweetland & Keyser 1983).

2.10.2 The use of content in entry-level tests

Most test batteries used at South African institutions of higher learning presently, contain content. From the examples cited above, only the test battery of Rutherford & Watson (1990) used as little content as possible, although they later added a content test to their battery (Rutherford 1992). The other examples cited are all achievement (content) tests.

The tests were designed specifically for the disadvantaged, but all contain subject-related content. The institutions claim that the entry-level tests are not used to deny students entry, but rather to broaden access, to advise students which courses to take and offer academic intervention programmes, and not solely for admission and selection purposes.

2.10.3 Type of items used, number of items and time allocated for test

The tests vary greatly with respect to this aspect. They differed as follows:

Wits Science Aptitude Test: 30 multiple items, 45 minutes.

Diagnostic Chemistry Test of Wits: 47 multiple items, 90 minutes.

Toledo Chemistry Placement Examination: 60 or 67 multiple-choice items, 55 minutes.

2.10.4 The test taker

All prospective students who apply for a science course at the different USA institutions are required to write the ACT or SAT (Sweetland & Keyser 1983). At Wits all chemistry 1 students who are already admitted write the diagnostic chemistry test (Huddle et al 1999).

At the University of Stellenbosch students applying for a course in the health sciences with averages of less than 85% in grade 11 write the Access Tests, and those with higher averages are encouraged to write them as a precautionary measure (van der Merwe 2000).

2.10.5 The uses of the tests

The tests are used to determine the level of preparedness for science courses at institutions of higher learning. They fulfil a diagnostic role and assist lecturers in identifying areas where the disadvantaged students need academic assistance. The Diagnostic Chemistry Test (of Wits) is used for placement within different difficulty chemistry I courses. The tests in the USA (Sweetland & Keyser 1983) are used to predict college performance and sometimes for admission and course placement in schools. The TASP (1998) is used to determine the preparedness of students for higher learning.

2.10.6 Topics covered in the test

The content breakdown for the Diagnostic Chemistry Test (Huddle et al 1999) is as follows:

6, 4 - 8,5 %	compounds and elements; concentration and stoichiometry; naming of elements, compounds

10,6 %	states of matter; Gas laws.
12,8%	amount of matter, the mole.
17,8%	reactions, stoichiometry; structure of matter.
21,3%	trends in the Periodic Table.

2.10.7 Success of the tests

Huddle et al (1999) reported that their tests were better predictors of academic success than Grade 12 results alone, whilst van Eeden et al (2001) reported that the Grade 12 results were a better predictor of future academic performance than their test battery. Van der Merwe (2000) reported that the grade 12 results combined with the Access Tests explain about 36% of the variance. These researchers continue to improve their existing tests (Botha 2000, Huddle et al 1999).

2.11 COMPENSATORY MODEL

It is widely acknowledged that the ultimate goal of any testing practice should be to eliminate inequalities in educational opportunity, and not how to counter differences in test scores (Cunningham 1986, Gronlund 1968, Scarr 1977).

However, as an interim measure and due to constraints of time and resources, compensation by means of a Compensatory Model that is explained hereafter, is in the interest of the country and morally inevitable at this point in time. Furthermore, low test scores, literally mean that the disadvantaged will not succeed at higher education without academic support. The disadvantaged need to be channelled to a level best suited to their level of preparedness and where their level of preparedness can be developed further.

2.11.1 Rationale for the Compensatory Model

The rationale of the model is based on four facts: tests measure present ability, present ability can be improved through education, the South African Government is keen to empower and uplift its people and most ex-DET learners are educationally disadvantaged.

Tests measure present ability (Brown 1983, Huysamen 1997). A learner's test score on an entry-level test should be interpreted as a measure of his/her present ability. It should not be misconstrued as his/her learning potential or inherent ability that is not changeable. It is indicative only of what the candidate was willing and able to do at the time of test taking.

Present ability can be improved by education and training (Brown 1983, Huysamen 1997, McCelland 1973). However, test scores are affected by, and do reflect, the inherent ability of the test taker, his/her motivation, the quality of schooling enjoyed, other learning experiences, his/her experience in test taking, test anxiety, etc. (Gronlund 1985). Of significance is that these factors can be improved through training and practice, which in turn can lead to better test performance. McCelland (1973) points out that there is not a single human characteristic that cannot be modified by training or experience. Hence, the test will determine the level of preparedness of the student and an intervention can develop this ability further.

At present, the education of the majority of the ex-DET learners remain at school level. Unless other measures are put in place to remedy the situation by further education, this waste in human resources, is counterproductive in a developing country which is keen to uplift and empower its people.

Bearing in mind the above factors and by using Zaaiman's (1996) definition of the concept 'disadvantage' (ex-DET learners from low income parents) and the test scores, test takers can be divided into three groups.

Group 1

Those who score high because they have the necessary ability to succeed and are well prepared for higher education. Their ability is not only attributable to good schooling and teaching, but as van der Merwe (2000:3) points out, "Potential and mastery of skills and

gaining of knowledge can never be separated,…" . The Science Competency Test will aptly identify this group of students.

Group 2

Those who score low but could also have the ability to succeed at higher education. Their low score is perhaps due to poor schooling and teaching practices and/or socio-economic circumstances that resulted in them not developing as they might have. The Science Competency Test is mainly concerned with this group and will try to identify this group.

The Science Competency Test that will be developed in this research will form part of a test battery. It is possible that students of Group 2 could do well in some of the tests and poorly in others. By looking at how they perform in the test battery as a whole this research will distinguish between this group and the next.

Group 3

Those who score low but are unable to better their performance due to personal traits are classed together under this group. Two trends are identified amongst this group.

This group consists of those who score low in the test because of their low ability. It is believed that this group will always score low regardless of schooling and teaching practices.

The other part is those who score low, but in fact have the ability to succeed academically. Their low test scores could be due to personal factors such as test anxiety and lack of motivation, etc.

The test will not distinguish between these two subgroups. They will be identified as one group.

2.11.2 Proposed Compensatory Model for the disadvantaged

The Science Competency Test of this research is primarily concerned with the identification of the Group 2 students. It is felt that their ability has remained under-developed by the

school system and that they are able to do better than what their test scores and poor Grade 12 results reflect.

The educational background of the ex-DET learners are far from ideal and their poor performance in content tests is well noted in literature (see Chapter 2 section 12). The proposed compensation for the effects of disadvantage on test scores should not be viewed as boosting of scores of low ability students for the sake of preferential treatment. Especially since Sharwood (1998) reports that of the disadvantaged students have succeeded academically with the aid of academic support. The proposed compensation should be seen as justified affirmative action.

As mentioned previously, test scores reflect the quality of past learning experiences. Therefore, the assessment of preparedness (as this research has set out to do) cannot be separated completely from the racial and cultural context in which it is embedded, since only people of colour were educationally disadvantaged during apartheid.

Two methods of compensation will be explored: a differential cut-off score profile and a statistical method (Huysamen 1997). The proposed placement of students within the higher education system will occur as follows:

Group 1 will enter mainstream science courses.

Group 2 will enter the Pre-Technician programme; this group will receive advice and counselling with regards to which courses to take and appropriate academic intervention would be offered to them to prepare them for mainstream courses.

Group 3 will not be admitted to the course.

In conclusion, the usefulness of a Compensatory Model that includes advice, counselling and educational intervention by the Port Elizabeth Technikon (PET) was mentioned. By implementing it, PET will be able to admit into mainstream only those students who are well-prepared; assist others to reach a level of preparedness to be able to enter mainstream later and it will be able to increase the access and success rates of its students.

2.12 CONCEPTUAL FRAMEWORK

2.12.1 Under-preparedness

Under-preparedness can be described under two headings: the conditions that lead to under-preparedness and the manifestations thereof in academic performance. Terms with a similar meaning that are also used in literature are disadvantaged, at-risk and underachiever. Attempts by researchers to measure disadvantage are mentioned.

2.12.1.1 Causes of under-preparedness in South Africa

The causes of under-preparedness noted in literature are poor schooling, political oppression, poverty, cultural factors, violence, social isolation (Miller 1997), behaviour problems, negative self-concept (Kok 1992), lack of educational stimulation in the home, unqualified or under-qualified teaching staff, the use of a second or third language as medium of instruction, lack of physical amenities and inadequate funding by Government.

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2.12.1.2 Manifestations of under-preparedness

Under-prepared students are not adequately proficient in the English language which is the medium of instruction at most South African institutions of higher learning, because it is not their mother tongue (Fourie & Naude- de Jager 1992). As a result, students do not fully comprehend the meaning of what they read and are unable to reproduce what they have learnt (Craig & Kernoff 1995). Consequently, they are unable to study and learn from English text.

Under-prepared students cannot differentiate between a good or bad text (Miller 1997, Parsons 1993). They are unable to produce a good text, they write poor essays, especially when answering test papers and assignments (Fourie & Naude-de Jager 1992, Miller 1997).

In their study of prospective physics and chemistry students, Fourie & Naude-de Jager (1992), reported that the under-prepared students differed from the prepared students in the handling of apparatus, the confidence in handling of the apparatus or equipment and the ability to put theory into practice. Botha (2000) reports on the poor numeracy and mathematics ability of the disadvantaged.

Gronlund (1985: 290) adds the following to the list: the disadvantaged is 'less verbal, more fearful of strangers, less self-confident, less motivated towards educational achievements, less competitive in the intellectual realm, more apt to be bilingual, less exposed to intellectually stimulating materials in the home, less varied in recreational outlets, less knowledgeable about the outside world and more likely to have attended inferior schools'.

2.12.1.3 Attempts to measure disadvantage

Zaaiman (1996) defined disadvantage in terms of home and school backgrounds of learners, their proficiency in practical work and their idea of what constitutes quality schooling. According to these criteria the majority of the ex-DET learners can be regarded as under-prepared for higher learning, although all are not under-prepared to the same degree.

The TASP (1998) test assesses skills and knowledge sanctioned by educators and test development committees, as necessary to succeed in higher education. Students who have not mastered the list of skills and knowledge, do poorly in the test, and are classed as under-prepared for higher education.

2.12.1.4 Summary

It is a truism that due to the previous apartheid regime, the South African school system failed to realise the full academic potential of ex-DET learners and ‘Coloureds’. These learners lag behind the White learners in terms of subject knowledge, basic academic skills, confidence and language proficiency. Their under-preparedness hampers any meaningful experience and interaction with academic work and growth within their academic life. As expected, they do not perform as required of a first year student.

All tests and examinations are taken in English which is not in the mother tongue of the disadvantaged. Under the circumstances, it is difficult to assess the disadvantaged accurately and also unfair to expect them to do as well as their White or Indian counterparts.

Underachievement due to under-preparedness in the USA is often attributed to laziness or lack of motivation to perform by the student (Miller 1997). In South Africa, it is mostly due to external factors outside of the control of the disadvantaged. Here the causes of under-preparedness have political origins and the terms ‘prepared’ and ‘under-prepared’ do not imply intelligent and stupid, respectively. Rather, a low test score is indicative of inferior schooling.

In a study of minorities, Scarr (1977) proved that the differential test performance of the two groups is due largely to cultural background differences and socio-economic disadvantage and not genetic characteristics.

The implication is that had ex-DET learners enjoyed the same privileges as the rest of the communities in South Africa, they would have done as well at higher education.

2.12.2 Knowledge

The research refers to two types of knowledge. The first type represents the first level in Bloom's Taxonomy of Educational Objectives (Krathwohl et al 1956) and is referred to as the recall of information. It excludes understanding or the meaning of the information (Ahmann & Glock 1971). Sometimes it requires relating the problem or information to other bits of material that will then trigger the memory (Krathwohl et al 1956). This type of knowledge is tested for in memory only/recall items in the Science Competency Test.

The second type refers to the knowledge assessed by the test as a whole - the science skills and 'knowledge ' of the student. Ebel (1972) refers to it as the 'command' of knowledge and it is achieved through thinking. It is information with its meanings, implications and significance attached (Ahmann & Glock 1971). The student's ability to use science

knowledge to make decisions, to solve problems or to create new knowledge is being tested. It is also referred to as the intellectual abilities or skills (Krathwohl et al 1956). The items that test this type of knowledge test understanding and application skills of the test taker.

2.12.3 Aptitude/Ability

The term 'aptitude' has become unpopular since many regard it as potential one is born with. As such, it is seen as part of your genetic make–up, something that you are born with or not and that you cannot acquire through learning or training.

The term ability is received more favourably and used henceforth. This ability is dependent on genetic characteristics as well as the environment (Brown 1983). It is not fixed, or unalterable, but can be enhanced through training and the seeking of appropriate knowledge (McCelland 1973, Scarr 1977).

An individual has many different abilities, e.g. the ability to play a musical instrument, the ability to swim well, or type quickly, the academic ability to perform well in science, etc. It is the comprehensive term that comprises many skills and includes personal and inter-personal skills, as well as specialised knowledge pertaining to that ability.

2.12.4 Skill

The researcher refers to general skills and experimental skills, which are collectively referred to as science skills. These skills represent some of the intellectual skills as in Bloom's Taxonomy of Educational Objectives where they are referred to as "organized modes of operation and generalized techniques for dealing with materials and problems" (Krathwohl et al 1956: 189) " to achieve a particular purpose" (Krathwohl et al 1956:190). Some skills may or may not need specialised knowledge to solve, but become an automatic operation or response. This automatic response can be acquired and enhanced through education and is a constituent of ability.

The general skills pertain specifically to science. The mental operations tested for include presenting data in precise and logical form, use of the correct units, extraction and evaluation of information from what is given, conversion of units and use of given formulae.

The experimental skills test knowledge about the handling and manipulation of the apparatus, accurate observation, systematic methods of work, and the ability to follow instructions for practical work and record results accurately and clearly.

2.12.5 Science competency

The term competency is a collective term. It includes the terms skill and knowledge as referred to by Ebel (1972). To be competent at anything requires skill i.e. the necessary mental operations and techniques and any specialised knowledge needed to perform the skill, as well as knowledge about the relatedness, significance and implications of that problem or material and the skill.

A science competency refers specifically to science skills and knowledge that renders one competent and proficient in science. In the context of this study, it differs from ability in that personal and inter-personal skills are not measured and therefore not implied in a science competency.

2.12.6 Total test score, S

The total test score was calculated (out of 30) using a formula that corrected for guessing. The formula (Lindeman 1967) was: $S = R - W/(n-1)$, where

- S = score
- R = number of right answers
- W = number of wrong answers
- n = number of optional answers

2.12.7 Item difficulty index, d

This value describes how difficult or easy an item is.

A value of d = 0.3 means that 30% of the sample got the answer right, whilst a value of d = 0.75 means that 75% of the sample had the right answer. Likewise, a value of d = 1 means that the item was answered correctly by all the test takers and a value of d = 0 means that the item was answered incorrectly by all the test takers.

A difficulty index of 0.5 is most suitable as this level provides the best discrimination between high and low achievers (Gronlund 1968).

The formula (Lindeman 1967) that was used in the calculation was:

Difficulty, d = (RH + RL)/(H +L), where

- RH = the number of right answers, high group
- RL = the number of right answers, low group
- H = number of students in high group
- L = number of students in low group

2.12.8 Discrimination index, D

One of the aims of the Science Competency Test was to distinguish between students having varying degrees of preparedness. The items were selected according to their ability to discriminate between students of different academic ability.

The discrimination index of an item describes its ability to discriminate between the high and low scorers in the sample. Values of between 0.4 - 0.6 are regarded as highly discriminating indices, whereas values of 0.3 – 0.4 are regarded as moderately discriminating only.

The discrimination index of items was calculated to detect any faulty items, especially those that discriminate negatively. Items that do not discriminate or that show reverse discrimination were discarded.

The formula (Lindeman 1967) for the discrimination index, D was

D = (RL - RH) / N, where

- RL = number of right answers in low group
- RH = number of right answers in high group
- N = number of students in high or low group (N = H = L)

2.12.9 Validity of test and items

A measurement tool is valid when it measures what it proposes to measure. The Science Competency Test will be used to predict the future academic performance of prospective science students. As such it needs to have a high predictive or criterion-related validity. This type of validity gives an indication of the extent to which the Science Competency Test accurately forecasts the future academic performance of the students.

There are three types of evidence, namely content-related, criterion-related and construct validity, that jointly give an indication of the validity of a test instrument. For the purposes of this test, the categories that will supply the most relevant information are the criterion-related validity and the content-related validity. Therefore, only these two types of validity were measured.

For the pilot testing, the school June examination mark was used as the criterion score. In this calculation each item was correlated against the school June examination mark. For the final Science Competency Test the semester average mark of the student was the criterion. The items and test score were correlated against this value in order to determine their ability to predict the criterion, that is the June examination mark or semester average mark.

The parameter that is measured is the significance (p-value). A p-value of less than 0.01 indicates a high significance or predictive power at the 99% level, whereas a p-value of less than 0.05 indicates significance at the 95% level. For example a test with a p-value of 0.01 is able to predict the semester average with 99% accuracy. For the purpose of this study, p-values of less than 0.01 are preferable, but values of up to 0.05 were also considered.

2.12.10 Reliability of a test

The term reliability refers to the consistency or stability of the measurement or test scores over a period of time. When similar results are obtained from two different administrations of the same test, the test has a high degree of consistency or reliability from one occasion to another.

The reliability of the Science Competency Test was determined through correlational analysis. This is an exercise to determine how two variables correlate with each other. A correlation coefficient, that is an r-value is obtained which can have the following possible values:

$r < 0$: an indication of an inverse relationship between the two variables.

$r = 0$: an indication of a chance relationship, meaning that the variables supply no information about each other.

$0 < r < 1$: an indication of varying positive correspondence between the two variables.

$r = 1$: an indication of a perfect positive relationship.

To determine the reliability of the Science Competency Test, the Cronbach alpha, was determined. The Cronbach alpha is a measure of the internal consistency of the test and entails an inter-item correlation.

2.13 CONCLUSION

This chapter gave a history on admission testing as well current developments in the field of admission testing. It also introduced a Compensatory Model to counter the effects of disadvantage on test scores and concluded with the conceptual framework. In the next chapter the experimental design adopted by the research is explained in detail.

CHAPTER THREE

RESEARCH DESIGN

3.1 INTRODUCTION

This chapter outlines the method of research and the different stages of the development of the Science Competency Test.

An entry-level test has distinct properties. Two of the most important properties of an entry-level test are the content it is supposed to cover and the predictive validity it should display. These properties determined the methods that were implemented in the research.

The study deemed it important that the content to be covered in the test be decided by the academics, namely the first year physics and chemistry lecturers who were in direct contact with first year students. Thus, a questionnaire was sent out to these lecturers with a request to indicate the content that should be covered.

In the quest for suitable items for the Science Competency Test, possible items were tried out in pilot runs. As many Grade 12 learners as possible were approached to write the pilot tests.

Both empirical and demographical data were collected from the pilot tests and test takers respectively. The empirical data about the items was used to assess the performance of the items and aided in the item selection process. The demographical data of the test takers included their last school attended and first language. These were used to ascertain their educational status in terms of advantaged or disadvantaged.

A description of the purposes and format of the Science Competency Test is given at the end of this chapter.

3.2 RESEARCH DESIGN

The different stages in the development of the Science Competency Test were gained from Ahmann (1962), Helmstadter (1964) and Gronlund (1968). An explanation of how each stage was dealt with as well as the goals of each stage is provided.

The basic stages in the development of the test were as follows:

- Draw up a test blueprint to specify the content to be covered in the Science Competency Test.
- Write test items.
- Pilot run test items.
- Analyse results of the pilot–run.
- Assemble final test.
- Administer the final test to first time first year science students.
- Appraise test results.
- Compile a test manual.

Following is an explanation of how each stage in the development was conducted.

3.2.1 Test blueprint

This stage of the development of the test included:

- The demarcation of the content to be assessed by the test. This study submitted the sections of the current Grade 11 and 12 physical science syllabi that are examinable in the Grade 12 final examination as a list of science skills and knowledge from which to choose.
- The interpretation of the identified science skills and knowledge in terms of learning outcomes.
- Choosing the most appropriate item format for each skill and knowledge to be assessed.
- Identification of the target group.
- Determining the length of the test, number of items, number of options and the duration of the pilot tests.
- Deciding on the number of items needed to assess a skill or knowledge.
- Designing the format of the answer sheet.

A questionnaire was sent to all first year lecturers of physics and chemistry at South African technikons to compile information about which science skills and knowledge contribute to the

academic performance in the first year. This same method was used to gather similar information by Huddle et al (1999), Mitchell (1989), The Texas Academic Skills Program (1998) and Russell (1994).

The fact that all technikon courses are national courses that cover basically the same syllabus enhanced the validity of the responses to the questionnaire (Sharwood 1998). The responses were collated and the items that received the most responses were chosen for the test.

Since the length and time frames of any test are practical considerations that must be taken into account, not all the skills and knowledge indicated by the responses in the questionnaires were included in the test.

3.2.2 Writing of test items

The writing and compiling of suitable test items was the most important exercise in the process of the test development. Both Gronlund (1968) and Cronbach (1970) rightly state that the drawing up of a quality test item is in itself a test. A quality test item has the right difficulty level, assesses the correct learning outcome, has the correct item discrimination, is able to predict the criterion, has the most suitable format and is free from any bias. Together the quality items form a quality test (Cronbach 1970, Gronlund 1968).

The pilot items were collected from various sources (Ball & Archer 1991, Boyd, Whitelaw & Warren 1991, Hill, Spiers, Tarrant and Woods 1969, Matthews 1975, McDuell 1989, Needham 1989, Porter & Woods 1987, Skevington 1988, Stephenson & Fisher 1983, Waddington 1984). Some items were used in their original state, some were rephrased and some were formulated by the researcher.

To ensure that all items were quality items the following pointers by Gronlund (1968) and Wood (1961) were considered in this phase:

- Does the item match the objective?

- What is the most suitable item format for assessing each individual skill and knowledge?
- Is the difficulty of the item appropriate?
- Is the item well-constructed?
- Is the item factually correct?
- Is the item free of technical errors and free from hints?
- Is the item is too wordy?
- Are the correct options spread over the entire range of responses?
- Is there only one correct option given?
- Are the options listed reflections of common errors?
- Do all the options have at least the same length so that the length does not become a clue?
- Is the question clear? All test takers should with certainty be able to determine what the item is asking of them.
- The item format used in the try-out phase should be the same as the one that is going to be used in the final test.
- In terms of the options, 'all of the above', 'none of the above', 'all' or 'none', Gronlund (1968) offers the following advice:
    - The options "all" or "none" should be used sparingly in the wrong options.
    - The option " none of the above" should be used mostly in instances where it is the correct option.
    - The option " all of the above" is not a good option to use.
- Are there enough items to cover the domain of the test sufficiently?
- Items should be free of any bias whether racial, ethnic or gender. Items should be free of bias in terms of vocabulary used, problem situation and unnecessary data. The vocabulary and problem situation in each item should be acceptable to all test takers and should have a similar meaning to all test takers. Unnecessary data in the item that would enhance the performances of some and lower the performances of others were omitted.

Cunningham (1986) advises that a table of specifications consisting of topics and the levels of Bloom's Taxonomy be drawn up as a means of ensuring content validity of a test. The information about each item was entered into the table. This allowed the researcher to confirm that there were items covering all the content and that each topic had items at the appropriate intellectual level.

Regarding the appropriate item format for the learning outcome to be assessed, Ahmann (1962) and Sweetland & Keyser (1983) mention that most achievement and ability tests are of the paper-and-pencil kind. Ahmann (1962) and Haladyna & Roid (1982) state that multiple-choice items are the most versatile of item formats and can be used to measure recall and the higher order cognitive abilities such as analysis and synthesis adequately. Cunningham (1986) endorses the use of multiple-choice items. He claims that written carefully, multiple-choice items can be used to assess understanding, calculation, explanation, prediction, interpretation and evaluative judgment. A good test presents each item as a novel problem and thus makes it impossible to answer the questions by memorising factual information.

Most American tests of achievement as well as the tests from Wits (Huddle et al 1999) and University of Stellenbosch (Botha 2000) are multiple-choice (Sweetland & Keyser 1983).

With regards to the assessment of laboratory skills, Thorndike (1982) states that these are better assessed by performance measure. The author points out that this assessment comprises a practical and a psychometric component and cautions that objectivity, uniformity and reliability in marking performance skills are nearly impossible to achieve.

3.2.3 Pilot run of test items

3.2.3.1 The target group

All first year applicants for a science course formed the target group. The majority of applicants were from the disadvantaged communities, spoke an African language and were from ex-DET schools. All applicants did mathematics and physical science in Grade 12.

3.2.3.2 The sample group

The three important issues of sample size, characteristics of sample and different locations from which the sample was extracted were adhered to.

In terms of sample size, items were tried out on as many Grade 12 physical science learners as possible at various schools in three different cities. This was done to achieve stable estimates of difficulty and discrimination indices of the test items.

Thorndike (1982) advises that more than one school should be involved in the pilot run in order to avoid the distortion of the item statistics due to some peculiarity of a school. By allowing more schools to write the test, it was hoped to minimise the effects of such peculiarities.

The sample group should reflect the characteristics of the target group as efficiently and as accurately as possible (Thorndike 1982). The characteristics that were given special attention were race, academic ability and science ability. The latter was confirmed by allowing only those who did physical science at Grade 12 level to write the tests. The PET admits students of all race groups and from different cultural backgrounds. It was therefore necessary to incorporate this property into the sample as well. Learners of all race groups wrote the test in three major cities in the country.

Schools in the disadvantaged areas were approached to write the pilot tests as it was felt that their learners would provide an equivalent group of test takers as the target group.

3.2.3.3 Test conditions

Care was taken to ensure that the testing conditions corresponded with those for the final test. The invigilators were fully briefed to adhere strictly to prescribed testing conditions.

3.2.3.4 Data

The test takers for the pilot run as well as the final test were asked to submit the following personal information:

- Their physical science June school examination mark. This was the only school examination mark available at the time of the pilot run and it was used as the criterion in the statistical analysis.
- Home language.
- Name of school attended.

3.2.3.5 Testing method

The pilot tests were administered from early August until the first week of October since most of the schools had completed the syllabi by that time.

The test-retest method was used to gather data about the reliability of the items. This method prescribes a six week interval between administrations to reduce the effects of memory on test performance (Gronlund 1985).

3.2.3.6 Duration of pilot tests

A time of one hour was set for the duration of the test. This awarded each test taker an opportunity to attempt all the items. In this way data was obtained about each item in the test.

3.2.3.7 Anticipated problems

At the time of the first administration, the course work done in that term was still fresh in the minds of test takers. It can be accepted that work covered in the first two terms was not fresh in their minds due to a three week June/July-recess between the second and third terms. The implication was that the items that covered the third term's work would be answered better than the previous two terms' work.

The second administration took place at the end of the third term, after a full scale September examination that is written in preparation for the Grade 12 final examination. This meant that

test takers would have revised the entire syllabi thoroughly. With the work freshly revised, performance in the second administration would be better than that of the first administration.

This is the normal course of events that takes place in all schools throughout the country. As can be seen, these are far from ideal circumstances for pilot testing.

In addition to this, most schools in the disadvantaged communities offer additional tuition after August until the September examination to ensure higher pass rates in the final examination. This also affected the test scores of the second administration.

Although the minimum six week period between administrations was strictly adhered to, the fear of growth and maturation remained real and practically unavoidable under the circumstances.

3.2.4 Analysis of test results of the pilot run

After the pilot run, the items were analysed statistically to determine their performance. The total test score, discrimination index, item difficulty index, predictive power and reliability of items were calculated.

For the statistical analyses the responses of the top 27% achievers (high,H) and the bottom 27% achievers (low,L) only were considered. The middle scorers were not used.

After the first round of pilot testing, there were not enough suitable items to constitute a full final test. More items were drawn up and the pilot testing was repeated with new and or reviewed items.

3.2.5 Compilation of the Science Competency Test

This phase entailed the selection of items for the final test. To do this the following were taken into account:

- Items with suitable predictive power, i.e. significant p-value were selected first.

- Difficulty level of the test as a whole was taken into account as a good spread of item difficulty index was sought.
- Items with suitable discriminating indices, D-values were selected as far as possible.
- Whether the items in total represented the domain of the test.
- Whether the items were free from overlap so that the information in one item did not provide a clue to the answer in another.
- Each item was a quality item in terms of section 3.2.2

3.2.5.1 Analysis of the Science Competency Test

The same analyses were carried out as for the pilot tests. These included the:

- Total test score.
- Difficulty index of the test item.
- Predictive power of test and test items. The first semester average mark was used as the criterion.
- Discrimination index of items.
- Reliability of the test.
- Item response analysis.
- Test bias.

3.2.5.2 Scoring of the Science Competency Test

This final phase included the following steps:

- Scoring the test. Three separate scores were calculated.
- Interpretation of test results.
- Setting selection standards.
- Developing a Compensatory Model.

3.3 DATA

The data consisted of both qualitative and quantitative data.

The research used a questionnaire that was sent to first year physics and chemistry lecturers at South African technikons to identify the core competencies to be assessed by the test.

Empirical data included the statistical analyses of the pilot test runs and that of the final test.

The physical science June examination school mark of all test takers in the pilot phase was collected.

The Technikon first semester mark of the test takers in the target group was collected and a semester average mark was calculated.

Other data included the home language, last school attended and Grade 12 final examination results. The Grade 12 results were used to calculate the Weighted Matric Score that is the entry requirement of the PET.

3.4 TEST MANUAL

This information about the test is intended for test users. The information included:

- The uses of the test.
- Instructions for the administration of the test.
- Statistical data such as the reliability and the validity of the test.
- Suggestions for the use of test results.
- Evidence on test bias.

3.5 SUMMARY

This chapter explained the process of the development of a Science Competency Test.

The next chapter explains how each stage in the development process was accomplished. It includes the outcomes and interpretations of the questionnaires, item selection process for Science Competency Test.

CHAPTER FOUR

THE SCIENCE COMPETENCY TEST

4.1 INTRODUCTION

In the compilation of the Science Competency Test into its final form six guidelines were followed. The guidelines were:

- Time allowed for the test.
- Number of items to be included in the test.
- Outcomes of two questionnaires. The questionnaires clarify important issues such as the content-domain of the test, the levels at which the content should be tested as well as the weight of the different sections in the test.
- The spread of item difficulty that will be implemented for the test.
- The relative significance of the statistical properties of item prediction, item difficulty and discrimination indices in an entry-level test and consequently in the item selection process.
- The item selection procedure to be followed in this research.

The initial part of the chapter explains the item selection procedure and the latter part provides a checklist of whether the outcomes of the questionnaires have been met.

The purposes and format of the Science Competency Test are explained in the sections that follow.

4.2 SCIENCE COMPETENCY TEST

The test items were designed to test science knowledge based on Bloom's Taxonomy of Educational Objectives of knowledge, understanding, application, problem-solving by means of familiar and unfamiliar situations (Krathwohl et al 1956). The Science Competency Test also measures general and experimental science skills, as well as practical work.

4.2.1 Aim of the Science Competency Test

The Science Competency Test will be used to quantify preparedness for higher education in all applicants including those from non-traditional educational backgrounds.

Depending on test scores students will

- Enter mainstream courses in science
- Be placed in the Pre-Technician course, which is the bridging programme of the PET.
- Be denied access and advised not to pursue a science course.

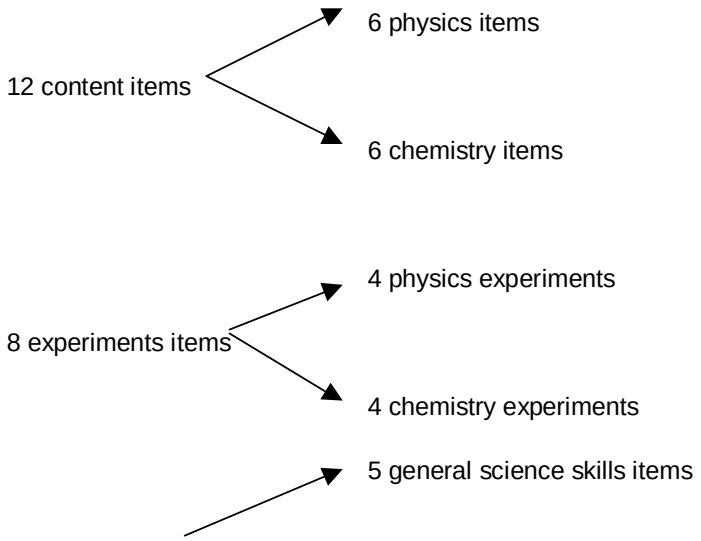
4.2.2 Objectives of the Science Competency Test

The main objective is to determine the level of preparedness of the student in terms of the relevant skills and knowledge the student has mastered at the time of test taking.

The Science Competency Test will yield three scores: two scores for the skill and knowledge sections each, and a total score to reflect the level of preparedness of the student.

4.2.3 Breakdown of the Science Competency Test

The Science Competency Test was designed to cover physics and chemistry equally. The items were divided into three main sections. The three sections are: content, practical work or experiments covered in Grade 11 and 12 and skills, which is further divided into a general science and experimental skills. Each section is further divided into two, one half to cover physics and the other to cover chemistry.



10 skills items → 5 experimental skills items

4.2.4 Factors that predict success in the sciences

First year lecturers of physics and chemistry at South African technikons ratified a list of science skills and physical science-specific content. The selected skills and content form the competencies used to predict future academic performance.

The specific outcomes of the questionnaires used to validate the skills and knowledge, will be discussed in detail from section 4.3 onwards.

4.2.5 Type of items, number of items and time allocated for the Science Competency Test

The Science Competency Test will form part of a battery of at least two other tests. It will cover physics and chemistry content. By taking into account the test battery and the content to be covered, the time for the test was set at 45 minutes.

The number of items in a test is always dependent on the time allowed for the test. Additional factors that contributed to the decision to include thirty items for the test, were:

- Only multiple-choice items would be used in the Science Competency Test.
- A wide spread of item difficulty would be implemented. To achieve this a reasonable number of items was needed to support the wide range.
- The Science Competency Test would cover both physics and chemistry disciplines. A decision to include fifteen items per discipline was made.
- All items would carry the same weight.
- Each item would test for a specific skill or knowledge.
- Each item would be posed at a specific cognitive level i.e. recall, understanding, application or problem-solving.

- The items would be of differential difficulty. The difficulty levels were categorised as easy, of medium difficulty, difficult or challenging.

A brief explanation of each category follows.

Easy: This is the first level on Bloom's Taxonomy of Educational Objectives. These items test recall only. It is expected that all students will attempt these items.

Medium difficulty: The problems posed by these items require one step reasoning to solve. These items test the understanding of content and are at a higher level than recall.

Difficult items: The problems posed by these items require more than one step to solve. These items test the intellectual levels of application, interpretation and analysis, by making use of familiar classroom situations.

Challenging items: These items are very difficult as the same levels of cognition as the previous category are assessed, but in unseen situations. It is expected that only the very adept student will attempt these items.

4.2.6 Basis for construction of the Science Competency Test

The Science Competency Test was designed to complement the existing test battery and to promote the predictive power, validity and reliability of the composite measurement of preparedness for higher learning in a science field.

4.2.7 Administration procedures for the Science Competency Test

The following standard test conditions were adhered to:

- A supervisor administered the test.
- Test takers were allowed to use calculators.
- The allocated time of 45 minutes was adhered to.
- Guessing was discouraged, as negative marking applied.
- Only one correct answer was given and students had to select the correct one from a choice of five.

- Formulae and physical constants that helped in the calculations were supplied.

4.3 THE QUESTIONNAIRES

The questionnaires are supplied in Annexure A and B.

A physics and a chemistry questionnaire were drawn up. Two copies of each was sent off to be completed by two physics and chemistry lecturers at all the South African technikons that offer any of Analytical Chemistry, Rubber Technology, Biomedical Technology or Environmental Health.

Eleven technikons offer the above four courses. The technikons are Border Technikon, Cape Technikon, Mangosuthu Technikon, M.L. Sultan Technikon, Technikon Northern Gauteng, Vaal Triangle Technikon, Witwatersrand Technikon, Technikon Natal, Pretoria Technikon, North West Technikon and Port Elizabeth Technikon. In all, twenty-two questionnaires of each kind were distributed. Thirteen chemistry and eight physics questionnaires were returned.

The ultimate aim of the questionnaires was to obtain a breakdown of the content of the Science Competency Test. The questionnaires were addressed to lecturers with first hand experience with first year science students and the course content of the first year physics and chemistry. Both questionnaires posed five questions. The first question was to select the topics. Only those sections from the Grades 11and 12 physical science syllabi that are examinable at the end of Grade 12 to be covered in a science entry-level test. Lecturers were also asked to indicate the level at which these topics should be tested for.

The level at which a topic, specifically content, should be tested for, refer to the intellectual levels of recall/memory, understanding and application. This information was needed to draw up items that would test a specific degree of command of a topic. Topics such as general and experimental skills had no level. Instead, lecturers had to indicate their relative usefulness or importance to a first year science student.

The second question was to select, from the same syllabi, the experiments to be tested for. This information served to reduce the twenty-five experiments that are listed in the syllabi to a manageable few that could be covered in the Science Competency Test. It was also necessary to find out whether the testing of practical work was regarded as important.

The third and fourth questions listed general science and experimental skills. The Department of Education and Science Welsh Office's (1985) National criteria for Physics and Chemistry offered a detailed list of general and experimental skills and the researcher decided to use it in this research. The lecturers were asked to indicate the skills they regarded as most useful or important in the first year of study.

The fifth question queried the weight that content, skills and experimental work should carry in a science entry-level test. This was done using a scale type measurement.

4.3.1 Interpretation of the questionnaires

The responses to the questionnaires are supplied in Annexures C and D.

The number of 'votes' or responses for each topic in question one was counted. Likewise, the responses for each level were also calculated. The topics with the most responses were selected for the final test. The level with the most responses for the selected topic was selected next.

Where the topics/levels received equal number of responses, the topics/levels that covered Standard Grade material were given preference to Higher Grade material. The reason for this was that Higher Grade learners cover Standard Grade work, whilst Standard Grade learners do not cover Higher Grade material. By choosing the Standard Grade material one is ensured that all test takers have covered the work. It also reduces the advantage that the few Higher Grade learners might have had over the majority of Standard Grade learners and makes the test more fair.

In question two the number of votes for each experiment was determined. Some experiments received equal number of votes. The experiments with the highest number of

votes were selected first and the remaining was selected by means of random choice from amongst those that scored equal number of votes.

Question three dealt with the general science skills. The same topics were listed in both questionnaires. An initial inspection was done to determine which topics received the most votes in each separate questionnaire. The results showed that the same skills were regarded as useful by both questionnaires. The votes of the two questionnaires were then combined and interpreted jointly.

Question four listed thirty-three experimental skills. Once again, both questionnaires listed the same thirty-three skills. Of these, three skills pertained to chemistry and two to physics only. Since the majority of the respective respondents did not vote these five skills as 'always important', the responses for this question were also combined.

Question five dealt with the weighting that each section (content, skills and experiments) should receive in a science entry-level test. The opinions of both the chemistry and physics lecturers were combined and counted jointly.

4.3.1.1 Weight of each section

The outcomes of question five were interpreted foremost since the weight of the different sections determined the number of items that was selected for each section. The combined responses for question five are shown in Table 4.1.

Table 4.1 The combined responses of the weight of each section

Number of Votes	Scale of Importance from 1 – 10									
	1	2	3	4	5	6	7	8	9	10
Content						6	2	3		7
Practical work	1	2	1	2	4	3	2	2		1
Skills		1	1			2	3	5	1	2

The number of responses received for each section on the scale from seven to ten was counted next. This end of the scale was selected because it was indicative of the ultimate importance of each section. The results were: 12 counts for content, 5 counts for practical work and 11 counts for skills.

The ratio/weight of each section was calculated by using the counts in the scale from 7 to 10. The formula used to calculate the ratio for each section was the number of votes scored by a section, divide by the total number of votes for all three sections for the scale 7 to 10, multiplied by 100. This percentage represented the importance (weight) of each section in the final Science Competency Test.

The calculations were:

Content: 12/28 x 100 = 42,8%

Experiments: 5/28 x 100 = 17,8%

Skills: 11/28 x 100 = 39,3%

4.3.1.2 Number of items per section

The number of items per section was calculated next. The formula used to calculate the number of items per section was the percentage for the section multiplied by the number of items in the test.

The calculations were:

Content: 43% x 30 items = 12.9items

Experiments: 17% x 30 items = 5 items

Skills: 39% x 30 items = 11.7 items

The aim of the research was to set up a science entry-level test that contained 50% physics and 50% chemistry content. The number of items for each section was therefore calculated to be an even number in order to further divide it into physics and chemistry items.

The number of items was rounded off to:

Content: 12 items

Experiments: 8 items

Skills: 10 items

The number of experiments was chosen as eight instead of six because experiments scored high in the scale 4-6 and because the researcher wanted the chemistry and physics sections of the test to balance.

The final weight of each section is shown in Table 4.2.

Table 4.2 Importance of each section in a science entry-level test

	Content	Skills	Experiment
Number of items	12	10	8
% Breakdown	12/30=40%	10/30=33%	8/30=27%

A breakdown of the sections, topics and number of items per section are shown in Table 4.3 below.

Table 4.3 The breakdown of the test

Section	Topic	Number of items
Physics	Content	6
Chemistry	Content	6
Physics and Chemistry	General Skills	5

Physics and Chemistry	Experimental Skills	5
Physics	Experiment	4
Chemistry	Experiment	4

With this knowledge the specific content, experiments and skills as well as the level of each content item could be determined next. To accomplish this the votes counted for questions one to four were interpreted first.

4.3.1.3 Selection of the physics content items

Eight physics questionnaires were completed and received back. The data used for the selection of topics were based on the feedback received from these eight questionnaires.

Only six physics content items were needed for the final test (see Table 4.3). The results of the vote count showed that most topics scored an equal number of votes. The vote count of only the top most votes are reflected in Table 4.4.

Table 4.4 Top most votes for physics content

Topic	Level with most votes	Number of votes received
Definition of scalar	1. Recall	5
Resultant of vectors	3. Application	5
Calculation involving	3. Application	6

$F=kq_1q_2/r^2$		
Definition of Newton	1. Recall	5
Calculation: work/energy/power	3. Application	5
Physical quantity and its unit	1. Recall	5
Definition of ohm	1. Recall	6
Definition of volt i.t.o. watt per amp	1. Recall	5
Definition of electrostatics	1. Recall	5
Definition of ampere	1. Recall	5
The unit watt	1. Recall	5

After the selection of the two topics with the most votes, the remaining four topics were chosen at random. The six physics content topics that were selected were:

- Definition of a scalar.
- Resultant of vectors.
- Calculation involving $F= kq_1q_2/r^2$
- Calculation involving Work/Energy/Power.
- Physical quantity and its unit.
- Definition of ohm.

In the final test the items that represented the physics content were items number 1, 4, 5, 8, 21 and 22.

4.3.1.4 Selection of the chemistry content items

Thirteen completed chemistry questionnaires were received. Of these, two were completed only from question 3.21 onwards. The questions 1 to 3.21 were therefore counted out of eleven and the remainder of the questions out of thirteen.

The chemistry content topics that received the most votes are shown in Table 4.5.

Table 4.5 Top most votes for chemistry content

Topic	Level with the most votes	Number of votes received
Solutions – standard	3. Application	6
Concept – reduction	2. Understanding	6

Concept – oxidizing agent	2. Understanding	6
Concept - reducing agent	2. Understanding	6
NO_2 – influence of pressure and temperature on the molecular composition of NO_2	2. Understanding	6
Definition -rates of reaction	2. Understanding	6
Dissociation equilibrium	2. Understanding	6
Dissociation of acids and water	3. Application	6
The basic principles of volumetric analysis	2. Understanding	6
Standardisation of acids and bases	3. Application	6
Oxidation and reduction - the electrochemical cell. Cu - Zn cell and its chemistry	2. Understanding	8
Comprehension and use of half - cell potential	2. Understanding	6
Definition - Organic Chemistry	1. Recall	8

Once again, most topics scored equal number of votes. After the topics with the most votes were chosen, the remaining four were selected at random.

The six chemistry content-topics selected for the final test were:

- Definition of organic chemistry.
- Oxidation and reduction - the electrochemical cell.
- Standard solution.
- Concept–reduction.
- Concept - oxidizing agent.
- NO_2 - the influence of pressure and temperature on the molecular composition of NO_2.

In the final test the items that tested for chemistry content were numbers 6, 11, 12, 17, 26 and 27.

4.3.1.5 Selection of the experimental skills

Five experimental skills were needed for the final test. The votes for the experimental skills of both questionnaires were combined.

Four of the thirty-three experimental skills listed pertained exclusively to physics whilst three pertained to chemistry. An initial count of the votes for these seven skills in the respective questionnaires revealed that they did not receive the top most votes. The results of this separate count were as follows:

Table 4.6 Separate count of skills

Physics	Votes received	Chemistry	Votes received
Analyse a ticker tape	2/8	Use a thermometer	4/11
Interpret a ticker tape	3/8	Dilute an acid	7/11
Use an ammeter	3/8	Use the redox half reaction table to balance equations	2/11
Use a voltmeter	3/8		

A second separate count was done. In this case, the number of votes scored by each skill in the respective questionnaires was counted. The skills that received the six top most votes in the respective questionnaires are listed in the table below.

Table 4.7 Top most votes for skills

Physics	Votes	Chemistry	Votes
*Systematic methods of	6/8	*Systematic methods of	11/11

work		work	
*Follow instructions for practical work	6/8	*Follow instructions for practical work	10/11
*Handle and manipulate physics/ chemical apparatus and material safely	6/8	*Handle and manipulate physics/ chemical apparatus and material safely	11/11
*Make accurate observations	5/8	*Make accurate observations	11/11
*Record accurately and clearly the results of experiment	6/8	*Record accurately and clearly the results of experiment	12/13
Interpret a graph	4/8	Make accurate measurements (being aware of possible source of errors)	10/13
Interpret results from an experiment	4/8		
Draw up reports	4/8		
Evaluate the results of an experiment	4/8		
Select appropriate apparatus	4/8		

The table shows that the five top most votes in the respective questionnaires were for the same skills.

Since the five skills that received the top most number of votes in the individual counts, would also score the most votes in the combined count, these skills were automatically selected for the final test. These skills are marked with an asterisk (*) in the above Table 4.7.

The items that tested for the experimental skills in the final test were item numbers 2, 3, 13, 14 and 29.

4.3.1.6 Selection of the general skills

Five general skills were needed for the final test. As mentioned earlier, the responses for the general skills were combined. An initial, separate count of the skills that received the six top most votes in each questionnaire was performed. The top six were counted although only five skills were needed for the final test. The results of this initial count can be seen in the two tables below.

Table 4.8 Initial count – physics skills

Topics: Physics	Number of votes
*Use of correct units	7/8
*Conversion of units	6/8
Use given formula	6/8
Apply laws and formula	6/8
*Extract and evaluate information from that which is given	7/8
*Present information in a precise and logical form	6/8
*Knowledge to solve problems	6/8

Table 4.9 Initial count – chemistry skills

Topic: Chemistry	Number of votes
*Use of correct units	12/13
*Conversion of units	10/13
*Extract and evaluate information from that which is given	10/13
*Present information in a precise and logical form	10/13
*Knowledge to solve problems	10/13
Be able to think logically	10/13

This separate count revealed that the same five skills received the top most number of votes by both questionnaires and are marked by an asterisk (*). The first four were automatically selected for the final test, as the same four would also score the top number of votes in a

combined tally. The fifth one of ' Knowledge to solve problems ' was rejected due to the fact that all test items require knowledge to solve and another one would be superfluous.

An alternative fifth skill was obtained by combining the votes of the two questionnaires. As was expected, the same four skills scored the most number of votes and remained selected.

In the remaining pool of skills, several scored the same number of votes. Therefore, the fifth skill was chosen at random. This fifth skill received 13/21 of the combined votes and was 'Use of given formula'. The other general skills that scored 13/21 votes in the combined tally were 'Apply principles' and 'Apply concepts'.

The selected general skills for the final test were:

- Use of correct units.
- Extract and evaluate information from that which is given.
- Conversion of units.
- Present information in a precise and logical form.
- Use of given formula.

In the final test the items that test for the general skills were item numbers 7, 10, 18, 20 and 23.

4.3.1.7 Selection of the physics experiments

The votes for each experiment were counted. The three experiments that scored a high of five votes were selected and the fourth vote was chosen randomly. The votes are reflected in Table 4.10.

Table 4.10 Top most votes for physics experiments

Topic	Number of votes received
The relationship between acceleration and force (constant mass)	5
The relationship between acceleration and mass (constant force)	5
Determine the resultant of two non-parallel forces acting at the same point	5
The relationship among three forces in equilibrium acting at the same point	4
The uniform velocity of a moving trolley leading to the graphs of displacement / time and velocity / time	4

The four physics experiments selected for the final test were:

- The relationship between acceleration and force (constant mass).
- The relationship between acceleration and mass (constant force).
- Determine the resultant of two non - parallel forces acting at the same point.
- The relationship among three forces in equilibrium acting at the same point.

The items that tested for the physics experiments in the final test were the numbers 15, 16, 28 and 30.

4.3.1.8 Selection of the chemistry experiments

The same process that was followed for the selection of the physics experiments was followed here.

The votes for each experiment were counted. Three experiments scored 7,8 and 9 votes respectively and they were selected automatically. The rest of the experiments scored equal votes. Once again, a random choice was made to select the fourth experiment. The individual votes of those experiments that scored the highest are shown in the next table.

Table 4.11 Top most votes for chemistry experiments

Topic	Number of votes received
Prepare a standard solution	9
Standardisation of a dilute solution of a base/acid using a standard solution of an acid/base	8
The relationship between pressure and volume of a given mass of gas (constant temperature)	7
Test for sulphates	6
The reaction of soluble chlorides, bromides and iodides with silver nitrate solution	6
The factors which affect the rate of reactions	6
The effect of temperature on the equilibrium in a chemical reaction	6

The four experiments selected for the final test were:

- Prepare a standard solution.
- Standardisation of a dilute solution of a base/acid using a standard solution of an acid/base.
- The relationship between the pressure and the volume of a given mass of gas (constant temperature).
- The effect of temperature on the equilibrium in a chemical reaction.

The items that tested for the chemistry experiments in the final test were numbers 9, 19, 24 and 25.

In the next step items were drawn up to test for the topics as specified above. Pilot tests containing the trial items were administered to Grade 12 learners. Afterwards the performance of the trial items was statistically analysed in order to find suitable items for the final test.

The statistical parameters within which the item selection occurred are explained in the section that follows.

4.4 STATISTICAL PARAMETERS

Item statistics are used to generate the most efficacious test. The selection of items with statistical properties best suited for an entry-level test, results in a test of high predictive validity and thereby increases its effectiveness and usefulness. The selection of items for the final test is guided by the item statistics.

A statistical analysis of an item is performed to evaluate the item's performance within a test. This performance is described through item statistics such as item prediction value, item difficulty and discrimination indices. Item statistics are also used to ensure that the test measures what it is suppose to measure. This is especially important since the entry-level test will be used to predict the future academic performance of students. Decisions as to who to admit to higher education need to be made. These are important decisions with major consequences involved for all. It is therefore critical that the test is most efficient in so far as it will enable the user to make the best decision regarding admissions.

The statistical analyses were computed for the items of all the first administrations (and not second administrations) of all trial tests. This was done because the conditions at the first administration related closest to the circumstances under which students take entry-level tests. The special conditions of first time exposure to an entry-level test and test material, the accompanied test anxiety and the condition of memory applies.

4.4.1 Item prediction, p-value

(see also 2.12.9)

This statistical property was given first preference in the selection process because an entry-level test requires a high predictive validity. Items with suitable item prediction values were selected first.

The prediction power of each item was calculated by determining its ability to predict the school June examination mark. p-Values of up to 0.05 were considered in the item selection. In certain instances values far greater than this were accepted when other conditions had to be satisfied. These exceptions occurred in the second and third rounds of item selection and involved item numbers: 1, 2, 3, 4, 6, 9, 10, 12, 13, 14, 15, 16, 23, 28, 29 and 30.

4.4.2 Difficulty index of items, d

(see also 2.12.7)

According to Thorndike (1982), a good spread of item difficulty is needed when making decisions about test takers who score over a wide range of the attribute being tested.

One of the aims of the selection process was to include items with item difficulty indices ranging from very easy to difficult. Therefore, all item difficulty indices were considered. The item difficulty index of the test ranged from 0.11 - 0.79, where a difficulty index of d = 0.11 indicates a difficult item and a value of d = 0.79 indicate an easy item.

4.4.3 Discrimination index, D

(see also 2.12.8)

The degree to which items discriminate between students of higher and lesser ability is significant to an entry-level test. Discriminating items increase the effectiveness of the test by allowing the test user to rank the test takers more effectively (Lindquist 1955).

All the items with negative discrimination indices were not selected. Items with discrimination indices between 0.4 - 0.6 were given preference, except where the conditions of the content validity, the spread of difficulty index and item prediction had to be satisfied.

4.5 THE ITEM SELECTION PROCEDURE

The main considerations in the selection process were the three statistical properties of the items as explained in 4.4 and the level at which content topics tested. The aim was to set up a test with significant predictive power, that discriminated sufficiently between the high and low achiever and with a wide spread of item difficulty. Items that promoted this aim were considered.

The selection of the best possible items that would generate the most effective final test, was laborious. The exercise was made more difficult due to the specific intellectual level of either recall/memory only, understanding or application at which the topics were supposed to test. Items were scanned to ascertain whether they were on the correct level, even before their statistical properties were taken into account.

Unfortunately, all trial items were not on the prescribed level. A decision to include such an item was made as this would preserve the content validity of the test. The items involved were numbers: 6, 12, and 22. This means that 3 out of 12 content items were not at the correct level.

The items were not selected in numerical order. The item selection was achieved in three decisive steps:

- Items with suitable item prediction values were selected first, thus securing the maximum number of items with suitable item prediction values for the test. It was felt that this would aid in the overall predictive power of the test.
- The items that were selected first did not cover a wide range of item difficulty index. Therefore, the consideration in the second step was to widen the range of item difficulty index.
- In the last round items were selected to support the item difficulty range set in the second round and to satisfy the content validity of the test.

Throughout the selection process an attempt was made to select the better statistics.

Lastly, the items were arranged in order of easiest to most difficult and numbered one to thirty.

The three steps are explained in more detail next.

4.5.1 Step 1

In accordance with the purpose for which the test will be used, item prediction values were used as the first criterion in identifying and selecting possible items. All items with item prediction-values in the acceptable range of $p < 0.05$ and that complied with the outcomes of content and level of the questionnaires were selected first. In some cases more than one item of the same topic was identified. Where this occurred, the item with the better item statistics was chosen.

Fifteen items were selected in this round. These were item numbers: 5, 6, 7, 8, 11, 17, 18, 19, 20, 21, 22, 24, 25, 26 and 27. Items 1, 4, 9, 10, 23 and 30 were also identified in this round, but were later sacrificed in favour of items with different item difficulty indices. Item 23 was not selected due to its negative discrimination index.

The level at which the items tested, was also checked. Of the selected items, numbers 6 and 22 were not at the prescribed level.

4.5.2 Step 2

The item difficulty range of the items selected in Step 1 was determined by arranging the selected items from lowest to highest item difficulty index. The item difficulty index range at 0.11 - 0.68, was too narrow. Hence, items with greater item difficulty indices were sought to widen the range.

To achieve a wider range, suitable item prediction values were sacrificed. The selection of items 1 to 4 was a case in point. However, care was taken to remain as close to the acceptable statistical parameters as possible since the four selected items tested at the correct levels. These four items rendered a spread of item difficulty index of 0.11 - 0.79. This range was subdivided into four groups. Five items were allocated to the lowest and the highest groups, whilst the middle groups were allocated 10 items each. The four items selected in the second step filled the group with the highest item difficulty index.

The subdivisions were as follows:

RANGE	No. of items in the range
0.65 - 0.82	5
0.47 - 0.64	10
0.29 - 0.46	10
0 - 0.28	5

The items selected in Steps 1 and 2 were placed into the subdivisions in order to check which item difficulty index slots remained open after Step 2.

The aim in Step 3 was to fill up the remaining open slots.

4.5.3 Step 3

In the previous two steps all items with the best item prediction values were selected and a suitable item difficulty range was established. At this stage nine items remained outstanding and nine item difficulty index slots had to be filled.

The selection of the remaining nine items was more restricting since the items had to comply with specific statistics, e.g.:

- Specific item difficulty indices to fit into the open spaces in the four groups.
- Complete the content-domain that remained open after Steps 1 and 2.
- Satisfy the statistical parameters explained earlier. This was especially difficult to achieve after Steps 1 and 2, and exceptions occurred more frequently than not.

Although the item with the 'best' item statistics was still sought, the item difficulty index of the items became the focus. In this round the statistical data of the trial items that tested for the same topic were tabled and compared and the 'best' possible item was selected.

Items selected in this final round were numbers 9, 10, 12, 13, 14, 15, 16, 23, 28, 29 and 30. Of all the items selected in this round, item 12 did not test at the prescribed intellectual level.

4.6 THE LEVELS OF CONTENT ITEMS

One of the outcomes of the questionnaires was that the 12 content items be posed at specific intellectual levels. The levels were:

- Recall/memory only
- Understanding/simple exercises
- Application/problem-solving/standard type problems

A brief explanation of each would be:

- Recall/memory only: no thinking is required to answer the question, only remembering of information.
- Understanding/simple exercises: requires demonstrating the meaning of information, shows inter-relatedness of things. Where a problem must be worked out, a mere one step towards solving the problem yields the answer.
- Application/problem-solving/standard type: the application of knowledge to solve problems or to create new meaning. Where a problem must be solved, two steps towards solving the problem are required. Only standard type questions are asked and only 'known' or 'seen' situations are referred to in the problems.

The content items are numbers: 1, 4, 5, 6, 8, 11, 12, 17, 21, 22, 26, and 27. The three items that did not test at the correct level were items number 6, 12 and 22.

Once the topics were selected, the votes for the levels at which the topics test, were counted. The level with the highest vote was selected.

Table 4.12 reflects the level at which each of the content items should be posed.

Table 4.12 Levels at which each content item will be posed

Content	Levels

	Recall/Memory Only	Understand/ Simple exercises	Application/ Problem-solving	Difficult More complex
Definition Of scalar	*			
Resultant Of vector			*	
Calculation: $\mathbf{F=kQ_1Q_2/r^2}$			*	
Calculation: Work/energy/ Power			*	
Physical Quantity and its Unit	*			
Definition of ohm	*			
Definition Of organic Chemistry	*			
Electrochemical Cell		*		
Standard Solution			*	
Concept of Reduction		*		
Concept of Oxidizing agent		*		
Nitrogen dioxide NO_2		*		

4.7 ITEM SELECTION FOR THE FINAL TEST

In the course of the research, seven pilot tests bearing the trial items were administered. The seven trial tests are included as Annexures. For the sake of clarity the following keys were used:

- Annexure E: Pilot Test - C1
- Annexure G: Pilot Test – C2
- Annexure F: Pilot Test – P1
- Annexure H: Pilot Test - P2
- Annexure I: Pilot Test - T1
- Annexure J: Pilot Test - T2
- Annexure K: Pilot Test - T3
- T1 (3) - Indicates item number 3 of Pilot Test T1

- * Indicates that the item was selected for the final test.

All first administration trial items were analysed statistically. Statistical values of item prediction, item difficulty and discrimination indices for all items were calculated.

In the discussion that follows each item is described according to its discipline section (physics or chemistry), what it tests (knowledge, skill or experiment) and where applicable the level at which it tests. The specific topic of each item is also given. All the trial items can be found in the pilot tests that are included as Annexures. Each trial item is numbered according to the trial test in which it appears.

A table with statistics of the trial items and the rationale for an item's selection is explained next. Although the items were not selected in numerical order, as explained earlier, the discussion which follows, is done in numerical order.

4.7.1 Item 1

- Section: Physics
- Knowledge: Level: Recall/memory only
- Topic: Physical quantity and its unit

As no specific physical quantity was mentioned in the questionnaire, different quantities were used in the item try-out.

4.7.1.1 Statistical analysis

The results of the statistical analysis of the items are shown in the Table 4.13.

The symbols used in the tables indicate the following statistical values:

- p-value: item prediction power
- d: item difficulty index
- D: discrimination index

Table 4.13 Statistics for Item 1

	T1 (3)	T1 (31)	T1 (36)	T2 (3) *	T3 (3)
p-value	0.724	0.219	0.628	0.904	0.036
d	0.58	0.13	0.47	0.79	0.62
D	0.41	-0.02	0.47	0.14	0.46

4.7.1.2 Selection of Item 1

In order to secure an upper limit for the item difficulty index range in the final test, the entire trial item bank was searched for items with high item difficulty indices. Very few items yielded high item difficulty indices. From these, items 1 to 4 were selected.

Unfortunately, all the items with high item difficulty indices produced insignificant item prediction values. These high item prediction values were overlooked in the quest for easy items.

The item T3 (3) was identified in the first step of the selection process due to its item prediction value, but was rejected in the second step when easy items of high item difficulty indices were sought to widen the range of item difficulty. Item T1 (31) was discarded due to its negative discrimination index.

The item T2 (3) with its high item difficulty index of 0.79 was selected in the second step. The inclusion of easy items at the start of the test was deemed necessary to instill confidence in the test taker. The selected item T2(3) forms the upper limit of the item difficulty range of the final test.

The required level for this topic was recall/memory only. From the options given for this item, mere recall of information was needed to get to the correct answer. The selected item T2 (3) was therefore at the required level of recall.

4.7.2 Item 2

- Section: Chemistry and Physics
- Experimental Skill: Level: Always important
- Topic: Handle and manipulate physics/chemical apparatus and material safely.

There were five trial items for this topic.

4.7.2.1 Statistical analysis

The statistics of all the items that tested for this experimental skill follow.

Table 4.14 Statistics for Item 2

	T1 (18)	T2 (18)	T2 (36)	T2 (40)*	T3 (18)
p-value	0.47	0.683	0.251	0.782	0.768
d	0.10	0.40	0.45	0.78	0.85
D	0.04	0.28	0.30	0.40	0.15

4.7.2.2 Selection of Item 2

As can be seen from the above table, this particular topic did not yield good results. All the item prediction values were unsatisfactory and the discrimination indices were very low. Only item T2 (40) showed a reasonable discrimination index of 0.40.

A possible reason for this poor performance could be the experimental nature of the topic, as learners from disadvantaged schools show a distinct under-preparedness in experimental knowledge and experience. This phenomenon is evident in other experimental topics as well.

Item T2 (40) was selected, solely for its item difficulty index of 0.78 in Step 2. As was the case with Item 1, this item was included as one of the easy items to start the test off with..

4.7.3 Item 3

- Section: Chemistry and Physics
- Experimental Skill: Level: Always important

- Topic: Follow instructions for practical work.

4.7.3.1 Statistical analysis

Statistics of all the items that tested for this skill:

Table 4.15 Statistics for Item 3

	T1 (17)*	T1 (38)	T2 (17)	T3 (17)	T3 (39)
p-value	0.565	0.174	0.765	0.171	0.74
d	0.75	0.15	0.36	0.54	0.23
D	0.24	0.10	0.30	0.31	0.15

4.7.3.2 Selection of Item 3

This topic did not yield good item statistics. The item prediction values were all $p > 0.1$ and not one of the discrimination indices was within the acceptable parameter.

Items T1 (17) and T2 (17) dealt with the electric circuit. In T1 (17) five circuits were given from which the correct one could be selected, whilst for T2 (17) the test taker had to draw the correct circuit AND calculate the reading on the ammeter. The additional step of calculating the reading of the ammeter, after having 'followed the correct instruction' (that is drawing the circuit) made this item more difficult than T1 (17).

As can be seen by its item difficulty index, item T1 (17) was easier because the student simply 'follow the correct instruction' (as is required by the topic), as the circuit is given. This enhanced the selection of T1 (17) as a more suitable choice.

As was explained under Items 1 and 2, item T1 (17) was selected for its high item difficulty index. Values of item prediction and discrimination indices were overlooked in the pursuit of obtaining easy items for the final test. Together with Items 1, 2 and 4 it makes up the four easy items of the test.

4.7.4 Item 4

- Section: Physics
- Knowledge: Level: Recall/memory only
- Topic: Definition of a scalar.

4.7.4.1 Statistical analysis

Statistics of the items that tested for this topic are given in the next table.

Table 4.16 Statistics for Item 4

	T1 (1)	T2 (1)*	T3 (1)
p-value	0.724	0.950	0.01
d	0.51	0.72	0.46
D	0.39	0.14	0.62

4.7.4.2 Selection of Item 4

For the selection of a suitable item for this topic, as was the case with the previous three items, 'favourable' item statistics were overlooked in favour of a high item difficulty index. Although the item T3 (1) was identified in Step 1 for its item prediction value, it was rejected in Step 2 in favour of an item with a higher item difficulty index.

The item selected was T2 (1). This item has the desired level, as it is a simple definition.

4.7.5 Item 5

- Section: Physics
- Knowledge: Level: Application/problem-solving/standard type
- Topic: Calculations involving work done, energy, power

Five trial items were drawn up to test for this topic.

4.7.5.1 Statistical analysis

Statistics of the items that tested for this topic are shown in the table below.

Table 4.17 Statistics for Item 5

	P2 (23)*	T1 (8)	T2 (8)	T3 (8)	T3 (32)
p-value	0.026	0.051	0.732	0.273	0.28
d	0.68	0.47	0.20	0.04	0.08
D	0.45	0.43	0.07	0.08	-0.15

4.7.5.2 Selection of Item 5

The trial items gave varying responses. The selected item, P2 (23), was identified in Step 1 because of its suitable item prediction value.

The selection was endorsed by the fact that the item tests for the topic at the recommended level. The problem that must be worked out in the item requires two steps to solve. This is in accordance with the definition of 'application'.

Most of the trial items tested at the correct level of 'application'. Item T3 (32) was discarded because of its negative discrimination index. Items T2 (8) and T3 (8) produced very low discrimination indices and unsuitable item prediction values. The item prediction value of T1 (8) was less satisfactory than that of P2 (23). Item P2 (23) was preferred to item T1 (8) because of its item difficulty index of 0.68.

4.7.6 Item 6

- Section: Chemistry
- Knowledge: Level: Understand (simple exercises).
- Topic: Concept - Reduction

4.7.6.1 Statistical analysis

Statistics of the items that tested for this topic are shown in the next table.

Table 4.18 Statistics for Item 6

	T1 (10)	T2 (10)	T3 (10)*	T3 (33)
p-value	0.075	0.545	0.011	0.177
d	0.31	0.53	0.65	0.31
D	0.47	0.47	0.69	0.0

4.7.6.2 Selection of Item 6

The item T3 (10) was identified in Step 1 for its significant item prediction value.

Scrutiny of the levels at which the trial items tested revealed that only item T3 (33) tested it on the recommended level. In order to get to the correct answer, it was required to know the definition of reduction AND to identify the concept within a chemical equation. However, this item was rejected because of its discrimination index of 0.0. Despite its incorrect level, item T3 (10) was selected for its item prediction value.

4.7.7 Item 7

- Section: Chemistry and Physics
- General Skill: Level: Always useful
- Topic: Use of correct units.

4.7.7.1 Statistical analysis

The statistics of the items that tested for this topic can be seen in the next table.

Table 4.19 Statistics for Item 7

	T1 (14)	T1 (31)	T1 (36)	T2 (14)	T3 (14)*
p-value	0.185	0.219	0.628	0.318	0.006
d	0.28	0.13	0.47	0.13	0.50
D	0.49	-0.02	0.47	0.16	0.69

4.7.7.2 Selection of Item 7

This topic is about a general skill that, except for item T3 (14), produced unsatisfactory item prediction values.

In the first step of the selection process, item T3 (14) was identified because of its acceptable item prediction value. It has a preferred item difficulty index of 0.5 and the 'best' item statistics of all the other trial items that tested for this topic.

Items T1 (14) and T2 (14) dealt with the same formula, but the unit of different quantities were asked. Both items produced weak item prediction values. Item T1 (31) was not considered for selection because of its negative discrimination index.

Item T1 (36) and the selected T3 (14) were similar and yet totally different item prediction values were obtained for them. This difference could be ascribed to the use of a formula in T3 (14) as opposed to the use of the term 'SI - unit' in T1 (36) in which to use the correct unit. Of these two items item T1 (36) generated an unfavourable item prediction value of p = 0.628 and was not chosen.

4.7.8 Item 8

- Section: Physics
- Knowledge: Level: Recall/memory only
- Topic: Definition of ohm

Four trial items tested for this topic.

4.7.8.1 Statistical analysis

Statistics of all items that tested for this definition are supplied in the table below.

Table 4.20 Statistics for Item 8

	T1 (4)	T2 (4)	T3 (4)*	T3 (31)
p-value	0.544	0.982	0.031	0.059
d	0.48	0.86	0.62	0.46
D	0.22	0.23	0.62	0.15

4.7.8.2 Selection of Item 8

This topic needed to be tested on a recall/memory only level. The item T3 (4) was identified in Step 1 for its adequate item prediction value. It also had a much better discrimination index than the other trial items in this section and tested on the desired level.

The item T3 (4) required the test taker to fill in two blank spaces, but the test taker knew that the spaces were related to the given quantity of 1ohm (resistance). This was a standard definition and having phrased it thus, it produced better item statistics. The item was on the recommended level as well.

In T1 (4) it was required to fill in a blank space by relating the quantities of V (potential difference) and I (current) to R (resistance). This item had the desired level, but an unsatisfactory item prediction value.

The item T2 (4) was very easy with an item difficulty index of 0.86, but its item prediction value and discrimination index were unsatisfactory when compared to the other trial items for this topic. The item T3 (31) had the lowest discrimination index of the trial items.

4.7.9 Item 9

- Section: Chemistry experiment
- Topic: Standardisation of a dilute solution of a base/acid using a standard solution of an acid/base.

4.7.9.1 Statistical analysis

Statistics of all items that tested various aspects of this experiment are shown in the next table.

Table 4.21 Statistics for Item 9

	C1 (7)	T1 (26)*	T2 (26)	T2 (33)	T3 (26)
p-value	0.045	0.575	0.608	0.316	0.446
d	0.18	0.60	0.42	0.55	0.58
D	0.30	0.37	0.37	0.58	0.08

4.7.9.2 Selection of Item 9

The trial items tested various aspects of the standardisation experiment. As was the case for other experimental topics all the trial items, except item C1 (7) produced poor item prediction values.

Items T2 (33) and C1 (7) were similar, with the former item giving the answer in a better 'phrased' option. This has improved the item difficulty as well as discrimination index, although the item prediction ability suffered.

The item T3 (26) yielded a very low discrimination index and was not considered for selection.

The items T1 (26) and T2 (26) tested the changes that take place at the completion of the standardisation reaction. These two items yielded the same discrimination indices, but the item T1 (26) was easier with an item difficulty index at 0.6.

The item C1 (7) was identified in Step 1 for its item prediction. However, as the selection process progressed an item with item difficulty index in the 0.47 - 0.64 subdivision was needed. In Step 3 of the selection process the item T1 (26) was selected instead and C1 (7) was rejected.

4.7.10 Item 10

- Section: Chemistry and Physics
- General Skill: Level: Always useful
- Topic: Conversion of units

Three items tested for this general skill.

4.7.10.1 Statistical analysis

Statistics of all the items that tested for this topic are given in the table below.

Table 4.22 Statistics for Item 10

	C1 (20)	C2 (3)	C2 (33)*
p-value	0.029	0.011	0.054
d	0.28	0.26	0.58
D	0.22	0.42	0.21

4.7.10.2 Selection of Item 10

The conversion of various physical quantities was tested under this topic. In some items, only one unit conversion was required, whilst in item C2 (3) four units had to be converted. The trial items yielded pleasing item statistics from which to make a selection. Only the item statistics were considered in the selection since no level was required.

Items C2 (20) and C2 (3) were identified in Step 1 of the selection process for their item prediction values. Although item C2 (3) produced the best item statistics, the item C2 (33) was selected at a later stage of the selection process for its item difficulty index.

4.7.11 Item 11

- Section: Chemistry
- Knowledge: Level: Recall/memory only
- Topic: Definition of organic chemistry

Only three items tested for this definition.

4.7.11.1 Statistical analysis

Statistics of all the items that tested for this definition are given in the next table.

Table 4.23 Statistics for Item 11

	T1 (6)	T2 (6)	T3 (6)*
p-value	0.985	0.51	0.026
d	0.25	0.44	0.58
D	0.37	0.09	0.54

4.7.11.2 Selection of Item 11

This topic had to be tested on a level of recall/memory only. The selection of a suitable item in this section was easy because all the trial items tested at this level.

The items compared as follows:

For the item T3 (6) it was required to identify the hydrocarbon, CH_4, and then relate this information to the fact that hydrocarbons are studied in organic chemistry. This item fulfilled the requirement of recall/memory only level.

Items T1 (6) and T2 (6) were direct definitions and therefore recall level also. However, they did not need an added relatedness to get to the answer. This could be the reason these two items generated unsatisfactory item prediction values and discrimination indices.

The item T3 (6) generated the best item statistics for this topic and was selected in Step 1.

4.7.12 Item 12

- Section: Chemistry
- Knowledge: Level: Understand (simple exercises)
- Topic: NO_2 - Influence of pressure and temperature on the molecular composition of NO_2

Three trial items tested for this content topic.

4.7.12.1 Statistical analysis

Statistics of all items that tested for this content can be seen in the table below.

Table 4.24 Statistics for Item 12

	T1 (11)	T2 (11)*	T3 (11)
p-value	0.659	0.501	0.871
d	0.24	0.57	0.35
D	0.04	0.21	-0.08

4.7.12.2 Selection of Item 12

This topic had to be tested on the level of 'understanding'. Unfortunately, not one of the trial items tested on the level of 'understanding'. All the items required mere recall/memory only responses.

In the selection, item T3 (11) was discarded because of its negative discrimination index.

Out of the remaining two items, T2 (11) was selected for its slightly better item statistics and to fit into a remaining open item difficulty level slot.

4.7.13 Item 13

- Section: Chemistry and Physics
- Experimental Skill: Level: Always important
- Topic: Make accurate observations

Five trial items tested for the topic of ' Make accurate observations'.

4.7.13.1 Statistical analysis

Statistics of all items that tested for this skill are supplied in the next table.

Table 4.25 Statistics for Item 13

	T1 (19)*	T1 (32)	T2 (19)	T2 (35)	T3 (19)
p-value	0.265	0.517	0.535	0.152	0.128
d	0.54	0.62	0.56	0.60	0.73
D	0.49	0.80	0.23	0.51	0.38

4.7.13.2 Selection of Item 13

All the trial items made use of novel examples and were generally of the same strength. Reasonably high item difficulty indices were obtained. As was the case for other skills topics, these items generated item prediction values of p >0.1, and as for most skills topics the choice of a suitable item could not be made on the basis of good item statistics. The selection of item 13 was left to the final stages of the process when items were selected on the basis of item difficulty indices only. Item T1 (19) was selected.

4.7.14 Item 14

- Section: Chemistry and Physics
- Experimental Skill: Level: Always important
- Topic: Record accurately and clearly the results of experiments.

4.7.14.1 Statistical analysis

Statistics of all the items that tested for this skill are in the next table.

Table 4.26 Statistics for Item 14

	T1 (15)*	T2 (15)	T2 (20)	T3 (20)
p-value	0.337	0.691	0.142	0.823
d	0.50	0.43	0.60	0.15
D	0.57	0.26	0.56	0.15

4.7.14.2 Selection of item 14

This topic deals with an experimental skill and produced item prediction values outside the recommended parameters of $p < 0.05$.

As all the trial items did test for the skill aptly, the search for a suitable item in this section relied on item statistics. Unfortunately, no single item produced suitable statistics and the alternative was to consider the item difficulty index of the trial items.

The item T1(15) was selected in the final round of the item selection process to fit into the lower half of the item difficulty index category of 0.47 - 0.64.

4.7.15 Item 15

- Section: Physics experiment
- Topic: The relationship between acceleration and mass (force constant)

Four trial items tested various aspects of this experiment.

4.7.15.1 Statistical analysis

Statistics of all the items that tested for various aspects of this experiment are shown in the next table.

Table 4.27 Statistics for Item 15

	T1 (22)	T2 (22)	T3 (22)*	T3 (35)
p-value	0.711	0.119	0.264	0.803
d	0.20	0.57	0.42	0.54
D	0.04	0.26	0.23	0.15

4.7.15.2 Selection of Item 15

All the trial items tested the relationship between mass and acceleration with a constant force, in different ways. Despite this, no item generated satisfactory item statistics. The items differed as follows:

Item T3 (35) was wordy and required a reason for the answer given. This item showed a low discrimination index as wells as an unsuitable prediction value. The discrimination index of T1 (22) was also very low at 0.04.

Item T2 (22) was a straightforward question that produced slightly better statistics, but it was rejected due to other items with better statistics within the same item difficulty subdivision.

Item T3 (22) contained very few words and only five simple diagrams from which to select the correct one. This item is different from the other mostly wordy items.

Being a topic that deals with experiments, the item prediction values obtained for all the trial items were once again unfavourable at $p>0.1$. The discrimination indices were also low. Therefore, a choice of item was made Step 3 only and then to fit into an open item difficulty index slot. The item T3 (22) was chosen for its item difficulty index.

4.7.16 Item 16

- Section: Physics experiment
- Topic: The relationship between acceleration and force (mass constant)

Four trial items tested for various aspects of this experiment.

4.7.16.1 Statistical analysis

Statistics of all the items that tested for various aspects of this experiment are shown in the next table.

Table 4.28 Statistics for Item 16

	T1 (21)	T1 (33)	T2 (21)*	T3 (21)
p-value	0.218	0.863	0.434	0.759
d	0.38	0.39	0.49	0.50
D	0.33	0.51	0.41	0.23

4.7.16.2 Selection of Item 16

Being an experimental topic, the item prediction values obtained for all the trial items were not good at p >0.2. The item T2 (21) was selected in the final round of the selection process to fit into a remaining open item difficulty index slot.

4.7.17 Item 17

- Section: Chemistry
- Knowledge: Level: Understand (simple exercises)
- Topic: Oxidation and Reduction - the electrochemical cell. Cu-Zn cell and its chemistry.

4.7.17.1 Statistical analysis

Statistics of all the items that tested for various aspects of this topic are in the table below.

Table 4.29 Statistics for Item 17

	T1 (7)	T2 (7)*	T3 (7)
p-value	0.092	0.018	0.563
d	0.37	0.45	0.0
D	0.12	0.44	0.0

4.7.17.2 Selection of Item 17

This topic deals with the understanding of any aspect of electrochemistry. Aspects such as the half reactions, apparatus used and the salt bridge were tested for under this section.

The item statistics varied, with the item that tested a well-known concept in detail, delivering the best statistics. The salt bridge is a common concept in electrochemistry. Item T2 (7) tested the full understanding of a salt bridge and fulfilled the requirement for this topic. Considering the options given, a full understanding of the functions of a salt bridge is required to answer the question. This item was on the correct level and was selected for its good item statistics in the first round.

Item T1 (7) was of the standard type, but proved not to discriminate well.

Item T3 (7) posed an unusual question about electrochemistry. This was not answered correctly by any of the test takers and had a discrimination index of 0.

4.7.18 Item 18

- Section: Chemistry and Physics
- General Skill: Level: Always useful
- Topic: Use of given formula

Only one item tested for this topic.

4.7.18.1 Statistical analysis

Statistics of the item that tested for this topic are shown in the next table.

Table 4.30 Statistics for Item 18

	P1 (12)*
p-value	0.007
d	0.42
D	0.58

4.7.18.2 Selection of this Item 18

This was the only item that tested for the 'use of a given formula' and it was therefore accepted. Its inclusion was well suited since it generated acceptable item statistics.

4.7.19 Item 19

- Section: Chemistry experiment
- Topic: The effect of temperature on the equilibrium in a chemical reaction.

4.7.19.1 Statistical analysis

The statistics of the items that tested for this topic can be seen in the table below.

Table 4.31 Statistics for Item 19

	T1 (29)	T2 (29)	T3 (29)*
p-value	0.277	0.006	0.002
d	0.33	0.35	0.42
D	0.16	0.33	0.69

4.7.19.2 Selection of Item 19

In the item try-out two types of chemical reactions were used. One had many reagents and products and the other had only one of each.

In the first type, the decrease or increase of any one of the reagents or products could be a possible answer. This could have lead to the low discrimination indices and lower item difficulty indices of the two items.

The items T1 (29) and T2 (29) each had a chemical equation with a few reagents and products in it. Both chemical reactions had heat as a product.

The third item, item T3 (29) dealt with the simple liquid-vapour equilibrium. Being a more everyday example and with only one reagent and one product, this item yielded more pleasing statistics.

Item T3 (29) was identified in the first round and was also selected for its best statistics compared to the other trial items.

4.7.20 Item 20

- Section: Chemistry and Physics
- General Skill: Level: Always useful
- Topic: Present information in a precise and logical form

Four items tested for this topic.

4.7.20.1 Statistical analysis

Statistics of the items that tested for this topic are shown in the next table.

Table 4.32 Statistics for Item 20

	T1 (40)	T3 (15)	T3 (36)*	T3 (37)
p-value	0.373	0.408	0.0	0.049
d	0.14	0.69	0.38	0.35
D	-0.08	0.46	0.46	0.23

4.7.20.2 Selection of Item 20

The trial items for this topic described novel situations and required the test taker to add to or change the information given in order to improve the presentation of its information.

The trial items compared as follows:

The items T3 (37) and T3 (36) were identified in the first round of the selection process, but T3 (36) was selected because of its better discrimination index.

The item T3 (36) was difficult because it required three calculations and the conversion of centimeters to meters. This seemed to increase the discrimination index of the item.

In item T3 (37) the diagram of the reaction-time chart was perhaps too congested.

To get to the correct answer for item T3 (15), no calculation was needed, since the answer was phrased. This rendered the item easier, but the item produced an unacceptable item prediction value of 0.408.

The item T1 (40) was not considered for selection because of its negative discrimination index.

4.7.21 Item 21

- Section: Physics
- Knowledge: Level: Application/problem-solving/standard type
- Topic: Calculation involving $F = kq_1q_2/r^2$

Three trial items tested for this content topic.

4.7.21.1 Statistical analysis

Statistics of the items that tested for this topic are shown in the next table.

Table 4.33 Statistics for Item 21

	T1 (30)	T2 (30)	T3 (30)*
p-value	0.902	0.331	0.002
d	0.40	0.44	0.38
D	0.25	0.37	0.46

4.7.21.2 Selection of Item 21

The trial items asked for the calculation of F, force or r, distance using the formula, $F=kq_1q_2/r^2$. A brief description of the performance of each item is given next.

The item T1 (30) required the calculation of r (distance) from the given formula of $F=kq_1q_2/r^2$.

The item T2 (30) needed the straightforward calculation of F (force), from the same formula.

Although force, F had to be calculated for item T3 (30) also, it had the added complication that only 'one' value for charge was given. The additional manipulation of the formula to determine force, gave this item the desired level of 'application'.

The selection of the item T3 (30) was based on its statistics and the fact that it was on the required level of application.

4.7.22 Item 22

- Section: Physics
- Knowledge: Level: Application/problem-solving/standard type
- Topic: Resultant of vectors.

4.7.22.1 Statistical analysis

Statistics of the items that tested for this topic are shown in the following table.

Table 4.34 Statistics for Item 22

	T1 (23)	T2 (31)	T3 (23)*
p-value	0.417	0.794	0.001
d	0.36	0.10	0.35
D	0.29	0.12	0.54

4.7.22.2 Selection of Item 22

Item T2 (31) tested additional concepts that were not specified by the topic. This item and the item T1 (23) produced unsatisfactory prediction values compared to item T3 (23) and were not on the required level.

The item T3 (23) generated the best statistics and was identified in step 1 for its significant p-value. The specific manner in which the options are presented and the fact that the

magnitude and direction of the term resultant are asked for separately, gave this item the desired level of application. This item was selected.

4.7.23 Item 23

- Section: Physics and Chemistry
- General Skill: Level: Always useful
- Topic: Extract and evaluate information from that which is given.

4.7.23.1 Statistical analysis

Statistics of the items that tested for this topic are given in the following table.

Table 4.35 Statistics for Item 23

	C2 (23)	T2 (15)	T3 (40)*
p-value	0.042	0.691	0.101
d	0.37	0.43	0.38
D	-0.05	0.26	0.62

4.7.23.2 Selection of Item 23

During the selection of an item for this topic, item C2 (23) was discarded because of its negative discrimination index.

The item T2 (15) was similar to item T3 (40). It required the test taker to place four metals in order of their reactivity, but its item prediction value was unsatisfactory.

The item T3 (40) qualified for the topic of 'extract and evaluate information' the best. This item asked how a fourth metal, that is the least reactive of the given examples, would react. The test takers had to look at the options given and evaluate them against the observations for the other three metals in order to choose the correct answer. Item T3 (40) was selected for the final test.

4.7.24 Item 24

- Section: Chemistry experiment
- Topic: Prepare a standard solution.

4.7.24.1 Statistical analysis

Statistics of the items that tested for this topic are given in the following table.

Table 4.36 Statistics for Item 24

	T1 (25)	T1 (37)	T2 (25)	T3 (25)*
p-value	0.939	0.336	0.298	0.043
d	0.11	0.24	0.43	0.35
D	-0.02	0.08	0.44	0.23

4.7.24.2 Selection of Item 24

This topic deals with an experimental/practical component of chemistry and like other similar items, produced unsatisfactory item statistics. Except for T3 (25) the rest of the trial items that tested for this topic produced item prediction values of $p > 0.2$.

Different aspects of this experiment were tested. The item T2 (25) tested the knowledge of a standard solution, whilst T1 (37) tested the knowledge required to calculate the amount of salt needed to make up the standard solution. This calculation proved difficult and generated an item difficulty index of 0.24.

The item T1 (25) was not considered for selection because of its negative discrimination index, whilst the item T1 (37) had a very low item discrimination index.

The selected item, T3 (25), asked why a volumetric flask instead of a beaker is used when making up a standard solution. The item is enhanced by means of a sketch of the two apparatus. Both the items T3 (25) and T1 (25) dealt with the use of the volumetric flask.

However, the item T3 (25) was phrased better and presented by means of the sketch than the discarded item T1 (25) and produced better statistics than T1 (25).

4.7.25 Item 25

- Section: Chemistry experiment
- Topic: The relationship between pressure and the volume of a given mass of gas (constant temperature)

Four items tested for various aspects of this experiment.

4.7.25.1 Statistical analysis

The statistics of the items that tested for this topic are in the following table.

Table 4.37 Statistics for Item 25

	T1 (27)	T1 (39)	T2 (27)	T3 (27)*
p-value	0.598	0.027	0.92	0.01
d	0.21	0.29	0.49	0.35
D	0.14	0.27	0.51	0.38

4.7.25.2 Selection of Item 25

The trial items dealt with various aspects of the experiment: the apparatus used, the results, the data recorded for the experiment, etc.

The item T2 (27) was a simple question about what to remember when conducting the experiment. It generated an unsatisfactory item prediction value of 0.92, although the other statistics were satisfactory.

The items T1 (27) and T1 (39) required knowledge of pV =k to solve.

The item T3 (27) was selected in Step 1 on the basis of its significant p-value of 0.01. It dealt with the apparatus used in the experiment. This very simple question yielded the best item statistics of all the trial items and was selected.

4.7.26 Item 26

- Section: Chemistry
- Knowledge: Level: Understand (simple exercises)
- Topic: Concept - oxidising agent.

4.7.26.1 Statistical analysis

Statistics of the item that tested for this topic can be seen in the next table.

Table 4.38 Statistics for Item 26

	C1 (19)*
p-value	0.019
d	0.28
D	0.41

4.7.26.2 Selection of Item 26

The item C1 (19) was the only item that tested for this topic. The item produced adequate item statistics of item prediction and discrimination index. It is a good item because it tests the understanding of the concept of oxidising (and reducing) agent in a chemical reaction and in the fact that the substance that is oxidised is the reducing agent. This item has the desired level, as a real understanding of the concept is necessary when searching through the options for the right answer.

4.7.27 Item 27

- Section: Chemistry
- Knowledge: Level: Application/problem-solving/standard type
- Topic: Solutions - standard solution

4.7.27.1 Statistical analysis

Statistics of the items that tested for this topic are given in the next table.

Table 4.39 Statistics for Item 27

	T1 (9)*	T2 (9)	T2 (39)	T3 (9)
p-value	0.006	0.954	0.376	0.132
d	0.23	0.51	0.62	0.31
D	0.22	0.56	0.72	0.31

4.7.27.2 Selection of Item 27

The level at which this topic tested was application, which is at a higher level than understanding. The items T2 (9) and T2 (39) are mere definitions and therefore not on the required level. Item T3 (9) tests understanding of the concept of standard solution.

In order to get the correct answer for the item T1 (9), the test taker had to know that the concentration of a standard solution is known, but that it is not ALWAYS the same value. The word 'always' in the question puts this at a higher level than mere recall or understanding. A temperature-value is also given to further test the real knowledge of what a standard solution is. The item was thus made difficult by the word 'always' and adding a temperature. The item has the desired level.

The item T1 (9) was identified in the first round because of its item prediction value. The selection of this item was easy because it offers the best item statistics of all the trial items under this heading.

4.7.28 Item 28

- Section: Physics experiment
- Topic: Determine the resultant of two non-parallel forces acting at the same point

Three items tested for various aspects of this physics experiment.

4.7.28.1 Statistical analysis

Statistics of the items that tested for this topic are given in the next table.

Table 4.40 Statistics for Item 28

	T1 (34)*	T2 (23)	T3 (23)
p-value	0.592	0.511	0.001
d	0.21	0.28	0.35
D	0.29	0.37	0.54

4.7.28.2 Selection of Item 28

Although three items tested for this topic, item T3 (23) was chosen as item number 22 of the Science Competency Test since it could be used to test the 'resultant of vectors' as well.

Two items remained from which to choose. Item T1 (34) was chosen because the already selected items in the difficulty index range of 0.1 - 0.28, fitted into the top half of this range. With its item difficulty index of 0.21 it would fit into the lower half of this item difficulty index range. This item was selected in Step 3.

4.7.29 Item 29

- Section: Physics and Chemistry
- Experimental Skill: Level: Always important
- Topic: Systematic methods of work.

Five trial items tested for this experimental skill.

4.7.29.1 Statistical analysis

Statistics of the items that tested for this topic are given in the next table.

Table 4.41 Statistics for Item 29

	T1 (16)*	T2 (16)	T2 (34)	T3 (16)	T3 (38)
p-value	0.638	0.231	0.334	0.193	0.257
d	0.46	0.15	0.20	0.62	0.12
D	0.18	0.30	0.21	0.31	0.23

4.7.29.2 Selection of Item 29

All items tested the systematic method of solving an experimental problem by placing the steps in systematic order. The items were novel, but everyday situations were used as examples.

All the trial items had item prediction values of $p > 0.1$ and discrimination indices <0.4. Therefore, the item T1 (16) was selected in the last round of the selection process, when items were selected to fit into open item difficulty index slots.

This topic is an important experimental skill for both chemistry and physics and with an item difficulty index of 0.46 item T1 (16) was one of the better items to choose for this topic.

4.7.30 Item 30

- Section: Physics experiment
- Topic: The relationship among three forces in equilibrium acting at the same point.

4.7.30.1 Statistical analysis

Statistics of the items that tested for this topic are supplied in the next table.

Table 4.42 Statistics for Item 30

	T1 (24)*	T2 (24)	T2 (38)	T3 (24)
p-value	0.086	0.874	0.229	0.003
d	0.11	0.49	0.40	0.31
D	0.14	0.47	0.37	0.31

4.7.30.2 Selection of Item 30

The item T3 (24) was identified in Step 1 due to its item prediction value.

From the above four trial items which tested for this topic, item T1 (24) was selected for its item difficulty index of 0.11. This item was the most difficult item chosen and as such formed the lower limit of the item difficulty range of the test. Also, it is one of only two items in the final test in which two options are correct, 'd. 2, 3.'

4.8 SUMMARY OF THE ITEM SELECTION

The selected items were arranged from highest to lowest item difficulty indices. The items were numbered from the end with the highest item difficulty index (i.e. the easiest items first). This allowed the students with lesser ability to answer the first few items with ease and to encourage them. It also served to ensure that test takers who did not finish the test paper, did not omit items that they could have answered correctly.

The item difficulty index range of the final test was 0.11 - 0.79. The number of items per subdivision changed and is shown in the next table.

Table 4.43 Number of items per subsection

Groups	No. of Items
0.65 - 0.82	6
0.47 - 0.64	9
0.29 - 0.46	11
0.1 - 0.28	4

The outcome of the questionnaires in terms of the content-domain was satisfied. Only nine out of twelve content items tested on the prescribed levels. The breakdown of the weight of each section in the test was maintained as was the balance between physics and chemistry.

Table 4.44 shows a summary of the statistical properties of each selected item. The compiled final Science Competency Test is included as Annexure N.

Table 4.44 Statistics of the selected items

Item no.	Item selected	Item Prediction	Item Difficulty index	Discr. Index
1	T2 (3)	0.904	0.79	0.14
2	T2 (40)	0.782	0.78	0.4
3	T1 (17)	0.565	0.75	0.24
4	T2 (1)	0.950	0.72	0.14
5	P2 (23)	0.026	0.68	0.45
6	T3 (10)	0.11	0.65	0.69
7	T3 (14)	0.006	0.5	0.69
8	T3 (4)	0.031	0.62	0.62
9	T1 (26)	0.575	0.6	0.37
10	C2 (33)	0.054	0.58	0.21
11	T3 (6)	0.01	0.58	0.54
12	T2 (11)	0.501	0.57	0.21
13	T1 (19)	0.265	0.54	0.49
14	T1 (15)	0.337	0.5	0.57
15	T3 (22)	0.264	0.42	0.23
16	T2 (21)	0.434	0.49	0.41
17	T2 (7)	0.018	0.45	0.44
18	P1 (12)	0.07	0.42	0.58
19	T3 (29)	0.002	0.42	0.69
20	T3 (36)	0.0	0.38	0.46
21	T3 (30)	0.002	0.38	0.46
22	T3 (23)	0.001	0.35	0.54
23	T3 (40)	0.101	0.38	0.62
24	T3 (25)	0.043	0.35	0.23
25	T3 (27)	0.01	0.35	0.38
26	C1 (19)	0.019	0.28	0.41
27	T1 (9)	0.006	0.23	0.22
28	T1 (34)	0.592	0.21	0.29
29	T1 (16)	0.638	0.46	0.18
30	T1 (24)	0.086	0.11	0.14

4.9 CONCLUSION

Of the 30 items selected 7 items had statistical properties within the acceptable parameters. These included item numbers 5, 11, 17, 18, 20, 21, 22 and 26.

Six items, numbers 7, 8, 19, 24, 25 and 27 had acceptable item prediction values, but not discrimination indices.

Five items had acceptable discrimination indices, but not item prediction values. These were items 2, 10, 13, 14 and 16.

The eleven items numbered 1, 3, 4, 6, 9, 12, 15, 23, 28, 29 and 30 did not have acceptable item prediction values nor discrimination indices. As was explained in section 4.7 each item

was chosen for a specific reason. The aforementioned eleven items, although without favourable item prediction power and discriminating ability, satisfied issues of content coverage and item difficulty indices. Thus enabling the final science entry-level test to meet the outcomes of the questionnaires.

4.10 FURTHER COMMENTS

The items that are selected depend on the selection procedure that was implemented. Different procedures result in different tests, albeit the same pool of trial items from which the selection is made. A few illustrations are given next.

If one starts off by establishing an item difficulty index range and then proceed to fill in the item difficulty subdivisions, a different test evolves from the Science Competency Test.

Alternatively, if one selects the item with the best item statistics for each topic, the result will be a different test from either of the two mentioned already. In this case a spread item difficulty index is sacrificed.

The aforementioned illustrations were carried out and yielded three different tests (including the final Science Competency Test) with at least 12 items common to all three tests. In other words, when any two of the tests are compared to each other at least 18 items are new.

During the item selection process of the Science Competency Test the discrimination index of items was not given equal emphasis as item prediction or item difficulty index. This option will also generate a different test.

Other factors that determine the selection of a particular item are:

- How to fill a subdivision of item difficulty index: is it filled with any value within the subdivision or is the top half as well as the bottom half of the subdivision. For example if the sub - division is 0.1 - 0.4, is it filled with any value which falls within this range, or is it filled with values greater than 0.25 and values less than 0.25?

- An acceptable item difficulty index range: is it of necessity between the easiest and the most difficulty item in the pool?
- The guidelines that should be followed in setting up an entry-level test: are the item prediction values and 'best item statistics' more significant than a reasonable spread of item difficulty index range? To what extent should one or the other be compromised?

All the factors mentioned determine the decision to select an item. Depending on which factor is regarded as more significant by the developer, a particular item gets selected.

4.11 SUMMARY

The entire process of developing and administering pilot tests and the subsequent evaluation of the pilot items was explained. The selection of the items for the Science Competency Test was elaborated upon, and supported by statistical information.

The next chapter supplies the test results obtained for the Science Competency Test after it was administered to the target group of first year science students.

CHAPTER 5

RESULTS OF THE STUDY

5.1 INTRODUCTION

The effectiveness of the Science Competency Test as a testing instrument was assessed through statistical measures.

As was done in the pilot run, the performance of the test items of the Science Competency Test was evaluated by comparing their predictive power, discrimination and item difficulty indices. The test's reliability and predictive ability were determined. The ability of the Science Competency Test and the Weighted Matric Score (WMS) to predict the Semester Average (SA) score, separately as well as combined was also computed.

The performance of the advantaged and disadvantaged groups in the test as a whole and in its subsections was determined, as well as the influence of home language on test scores.

All the statistical computations and results are explained in this chapter.

5.2 RESULTS OF STATISTICAL ANALYSIS

5.2.1 Sample

The number of first year science applicants who wrote the developed Science Competency Test of this study was 179. The applicants were first time, or prospective first time, first years.

Five dependent variables were considered during the analyses. The dependent variables were home language, educational background, course the student enrolled for at PET, the Weighted Matric Score (WMS) of the student and the Science Competency Test Score. The independent variable was the average semester mark achieved in the half-year examination.

Learners that attended schools situated in previously disadvantaged communities were categorised as educationally disadvantaged. Those learners who attended schools situated in White areas were categorised as educationally advantaged.

The students in the sample followed two types of study programmes. The Extended programme allowed students an extra year in which to complete a course, whilst the Normal programme stipulated a minimum number of years in which to complete a course.

A breakdown of the sample according to the different variables is given next. The following abbreviations apply:

- SCT – Science Competency Test
- SA – Semester Average
- WMS – Weighted Matric Score

Home language

- A Afrikaans
- E English
- SS South Sotho
- X Xhosa

School attended

- A Advantaged school
- D Disadvantaged school

Programme

- E Extended programme
- N Normal programme

The Table 5.1 reflects the breakdown of the sample according to home languages.

Table 5.1 Frequency as per home language

	Frequency	Percent
Unknown	1	.6
A	34	19
E	21	11.7
Setswana	34	19
SS	4	2.2
X	85	47.5
Total	179	100

One applicant's home language was unknown.

The sample was also analysed according to its educational (school) background. Table 5.2 reflects the breakdown of the sample on the basis of educational background.

Table 5.2 Frequency as per advantaged/disadvantaged educational background

	Frequency	Percent
Unknown	1	.6
A	31	17.3
D	147	82.1
Total	179	100

One applicant's school background was unknown.

The students in the sample followed five different courses, namely Analytical Chemistry, Biomedical Technology, Radiography, Environmental Health and Pre-Technician programme.

A breakdown of this is given in Table 5.3.

Table 5.3 Frequency as per course group

	Frequency	Percent
Analytical Chemistry	23	12.8
Biomedical Technology	15	8.4
Environmental Health	33	18.4
Pre-Technician	86	48
Radiography	22	12.3
Total	179	100

The entrance requirement, WMS differed for each course. Since WMS was a dependent variable in the empirical measurement, the sample was divided into its five course groups. Separate analyses were done for each group due to the different entrance requirement for each group. Only the analyses about the test items were carried out for the sample size, N = 179.

Not all the students within a course followed the same programme. Some followed a normal and others an extended programme. The Table 5.4 reflects the number of students in each of these programmes.

Table 5.4 Frequency as per normal/extended course programme

	Frequency	Percent
Valid	32	17.9
E	101	56.4
N	24	13.4
NA	22	12.3
Total	179	100

In the above table, the term Valid refers to the number of cases that were accepted for a course to begin in the new year (i.e. prospective students), and the NA refers to the number of cases that wrote the ST, but were not accepted for any course.

From the table it is clear that the majority of the sample were in the extended programme.

5.2.2 Swedish rating system/Matric rating system

This rating system is a point system based on the applicant's Grade 12 subjects and results.

The comprehensive rating schedule that is used in the faculty of Applied Science is shown in table.

Table 5.5 Matric rating system

Grade 12 Symbol	A	B	C	D	E	F	G
Higher Grade	8	7	6	5	4	0	0
Standard Grade	6	5	4	3	2	1	0
NTC3 (National Training Certificate 3)	5	4	3	2	1	0	0
Pre-Technician Course	8	7	6	5	4	0	0

The F and G symbols are not taken into account for all the courses in the calculation of the WMS. Also, not all the Grade 12 subjects are used in the calculations. The subjects and the symbols that apply in the calculation are stipulated by each course.

In the calculation of the WMS, each specified subject is multiplied by a weighting factor, which differs from course to course. An example of the subjects and their weighting factors are shown in the next table.

Table 5.6 WMS – weighting factors

Course	Grade 12 subject	Weighting factor
Pre- Technician Programme	Physical Science English Mathematics Biology Technical Subjects All others	x4 x3 x3 x2 x2 x1
Analytical Chemistry	Physical Science Mathematics English Home Language	x4 x4 x1 x1
Biomedical Technology	Physical Science Mathematics Biology English	x3 x2 x2 x2
Environmental Health	Physical Science Mathematics Biology,Geography, History or Accounting English	x4 x3 x2 x1
Radiography	Physical Science Mathematics Biology All other subjects	x4 x3 x2 x1

The sum of the totals for each subject yields the WMS. A minimum WMS beyond which an applicant will not be admitted for a normal programme for each course is stipulated. Those scoring slightly less, but within an acceptable margin undergo aptitude testing.

An example of how WMS is calculated for the Pre-Technician course is shown in the next table.

Table 5.7 WMS – Pre-Technician programme

Subject	Grade	Symbol	Points	X Weighting factor	Total
English	HG	C	6	X3	18
Mathematics	SG	D	3	X3	9
Biology	SG	B	5	X2	10
Physical Science	SG	F	1	X4	4
Geography	HG	F	0	X1	0
Afrikaans	SG	E	2	X1	2
				WMS =	43

5.2.3 The predictive power of test items

The predictive power of each test item was determined. To achieve this each item was correlated with the SCT score using Pearson Correlation.

The correlations, as well as the significant p–values obtained in this calculation, are reflected in Table 5.8. The discrimination and item difficulty indices of each item are also shown in the table.

Table 5.8 Statistics of SCT items

Item no	Item Difficulty Index	Discrimination Index	Correlations	SCT
1	0.73	0.29	Pearson	0.253
			Sig. 2 tailed	0.001**
			N	179
2	0.79	0.08	Pearson	0.096
			Sig. 2 tailed	0.203
			N	179
3	0.63	0.33	Pearson	0.295
			Sig. 2 tailed	0.00**
			N	179
4	0.52	0.46	Pearson	0.349
			Sig. 2 tailed	0.00**
			N	179
5	0.41	0.40	Pearson	0.321
			Sig. 2 tailed	0.00**
			N	179
6	0.40	0.33	Pearson	0.284
			Sig. 2 tailed	0.00**
			N	179
7	0.48	0.42	Pearson	0.320
			Sig. 2 tailed	0.00**
			N	179
8	0.72	0.15	Pearson	0.206
			Sig. 2 tailed	0.006**
			N	179
9	0.68	0.48	Pearson	0.401
			Sig. 2 tailed	0.00**
			N	179
10	0.48	0.46	Pearson	0.358
			Sig. 2 tailed	0.00**
			N	179
11	0.51	0.35	Pearson	0.283
			Sig. 2 tailed	0.00**
			N	179
12	0.40	0.29	Pearson	0.246
			Sig. 2 tailed	0.001**
			N	179
13	0.77	0.25	Pearson	0.200
			Sig. 2 tailed	0.007**
			N	179
14	0.63	0.17	Pearson	0.095
			Sig. 2 tailed	0.206
			N	179
15	0.64	0.10	Pearson	0.071
			Sig. 2 tailed	0.342
			N	179
16	0.56	0.25	Pearson	0.283
			Sig. 2 tailed	0.00**
			N	179
17	0.33	0.38	Pearson	0.287
			Sig. 2 tailed	0.00
			N	179
18	0.49	0.40	Pearson	0.321
			Sig. 2 tailed	0.00**

Item no	Item Difficulty Index	Discrimination Index	Correlations	SCT
			N	179
19	0.41	0.23	Pearson	0.184
			Sig. 2 tailed	0.014*
			N	179
20	0.49	0.31	Pearson	0.286
			Sig. 2 tailed	0.00**
			N	179
21	0.28	0.40	Pearson	0.363
			Sig. 2 tailed	0.00**
			N	179
22	0.45	0.44	Pearson	0.339
			Sig. 2 tailed	0.00**
			N	179
23	0.45	0.23	Pearson	0.211
			Sig. 2 tailed	0.005**
			N	179
24	0.52	0.13	Pearson	0.106
			Sig. 2 tailed	0.157
			N	179
25	0.40	0.25	Pearson	0.173
			Sig. 2 tailed	0.021*
			N	179
26	0.26	0.19	Pearson	0.192
			Sig. 2 tailed	0.010**
			N	179
27	0.38	0.38	Pearson	0.326
			Sig. 2 tailed	0.00**
			N	179
28	0.15	0.13	Pearson	0.103
			Sig. 2 tailed	0.168
			N	179
29	0.41	0.23	Pearson	0.169
			Sig. 2 tailed	0.024*
			N	179
30	0.20	0.06	Pearson	0.097
			Sig. 2 tailed	0.195
			N	179

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01level (2-tailed)

5.2.4 Significance (p-value)

Out of a total of 30 items, 21 items were able to predict the test score at the 0.01 level and 3 items were able to predict at the 0.05 level. The remaining 6 items did not predict the test score and had significant p–values exceeding 0.05.

Items number 1, 3, 4,5, 6, 7, 8, 9, 10, 11, 12, 13, 16, 17, 18, 20, 21, 22, 23, 26 and 27 had significant p–values < 0.01.

Items number 19, 25 and 29 had p–values < 0.05.

The six items that did not have satisfactory p–values were numbers 2, 14, 15, 24, 28 and 30. None of the items had a negative correlation or negative p–value.

5.2.5 Item difficulty index, d

A wide range of item difficulty index was recorded. The highest item difficulty index recorded was 0.79 and the lowest value was 0.15.

Twelve items were considered to be difficult with item difficulty indices < 0.45. These were the item numbers 5, 6, 12, 17, 19, 21, 25, 26, 27, 28, 29 and 30, of which four items, (numbers 21, 26, 28 and 30) were answered correctly by only 29% of the sample.

Nine items were answered correctly by 55% of the sample with four of those answered correctly by 70% of the sample. The nine items were numbers 1, 2, 3, 8, 9, 13, 14, 15 and 16 of which the four items with item difficulty indices > 0.7 were numbers 1, 2, 8 and 13.

The remaining nine items had item difficulty indices between 0.45 and 0.55.

5.2.6 Discrimination index, D

The ability of each item to discriminate between the high and low scorers was calculated. Eight items showed a high degree of discrimination. These were items: 4, 5, 7, 9, 10, 18, 21 and 22. Items number 3, 6, 11, 17, 20 and 27 discriminated moderately with values between 0.3 and 0.39. All other items had discrimination indices below 0.3 and were thus unable to discriminate significantly.

None of the items displayed negative discrimination indices.

A comparison of the significant values and the discrimination indices of the items, showed that items number 4, 5, 7, 9, 10, 18, 21 and 22 had significant p–values and were able to

discriminate as well. Items number 3, 6, 11, 17, 20 and 27 were able to discriminate only moderately and had significant p–values. The items with a significant p–value at 0.01 level and no acceptable discrimination index, were numbers 1, 8, 12, 13, 16, 23 and 26 and at the 0.05 level were numbers 19, 25 and 29.

The items number 2, 14, 15, 28 and 30 had neither satisfactory discrimination indices nor significant p–values.

5.2.7 Item response analysis

An item response analysis was carried out where an item had unsatisfactory difficulty level and discrimination index. Since most items in the Science Competency Test fell in this category, an item response analysis was performed. The responses to each item by those in the higher and lower scoring groups were analysed. The statistical data obtained are included as Annexures O through R.

The result of this analysis indicated that for the lower scoring group, all the distracters (incorrect options) were selected at least once for each item, except for items number 1, 15 and 16. In the higher scoring group two distracters were not selected in six of the items and for two other items there were three distracters that were not selected. However, the other group selected distracters that were not selected by a particular group. Overall all distracters were selected at least once.

5.2.8 Performance in subsections of the Science Competency Test

The performance of the high and low scoring groups in the subsections of the Science Competency Test was analysed. The subtotals for the content, skill and practical work sections were calculated and a mean score for each section was calculated.

Both groups scored highest in the skills section. For the high scoring group the content section and thereafter the practical work section followed this. The low scoring group's second highest score was for practical work. The score obtained for practical work was very

similar to that for the skills section for the low scoring group. The low scoring group scored very poorly in the content section.

The median score for the different sections is shown in Table 5.9.

Table 5.9 Performance in subsections

	Median Score		
	Content (12 items)	Skills (10 items)	Experimental Work (8items)
High Scoring	8/12	7/10	4/8
Low Scoring	3/12	4/10	3/8

From the table the poor performance in the content section is very evident. The table also reflects that both groups did poorly in the practical work items. It would seem that practical work is not given satisfactory emphasis irrespective of school background.

5.2.9 Descriptive statistics

The descriptive statistics were computed separately for each course group and not for the sample as a whole.

The descriptive statistics made use of two predictor variables, SCT and WMS, and a criterion variable, SA. The other variables used were the home language and the educational background of the test takers.

The Radiography group did not have a SA mark and the Environmental Health did not have a WMS. Consequently, certain correlations could not be performed for these groups.

The different descriptive statistics that were carried out were the reliability analysis, mean SCT score, standard deviation and multiple regression analysis.

5.2.10 Reliability analysis–scale (alpha)

The reliability analysis was carried out to determine the reliability of the Science Competency Test for each course group. The value that was calculated was a correlation, r-value. An r-value of 0.6 is considered moderate and higher values means increasingly greater

correlation. The reliability coefficients for the different course groups are contained in Table 5.10.

Table 5.10 Reliability coefficient alpha as per course group

Course Group	Reliability
Biomedical Technology	0.29
Analytical Chemistry	0.09
Radiography	0.45
Pre – Technician	0.28
Environmental Health	0.77
Overall (N = 179)	0.51

The reliability coefficients for the Analytical Chemistry, Biomedical Technology, Pre–Technician and Radiography groups were less than 0.45. A good internal consistency of 0.77 was recorded for the Environmental Health group.

The reliability of the Science Competency Test for the sample N= 179 was a moderate 0.51.

5.2.11 Mean SCT score and standard deviation

The mean SCT score and standard deviation were calculated. The mean value is an indication of the average test score of the sample whereas the standard deviation explains the spread of the test scores. High SD values mean that the test scores were spreaded wide and low SD values mean that most test scores were similar. When the sample is of a wide ability range it large SD-values are favourable.

The mean SCT score and standard deviation (SD) for each group are shown in Table 5.11.

Table 5.11 Mean SCT score and Standard Deviation as per course group

Course group		N	Minimum	Maximum	Mean	SD
Anal Chem	SCT	23	11.00	22.00	16.78	2.98
	WMS	23	38.00	57.00	45.43	5.57
	SA	23	16.00	77.20	49.57	14.69
Biomed Tech	SCT	15	14.00	23.00	17.80	3.05
	WMS	14	20.00	63.00	40.29	10.70
	SA	15	27.60	89.60	58.57	16.51
Env Health	SCT	33	7.00	20.00	12.48	3.61
	WMS	0				
	SA	33	44.33	75.17	58.00	7.97
Pre-Tech	SCT	86	9.00	20.00	14.22	2.73
	WMS	80	20.00	68.00	47.04	9.34
	SA	54	7.60	76.60	47.91	10.14
Radiography	SCT	22	4.00	20.00	14.18	3.90
	WMS	20	26.00	86.00	56.65	14.74
	SA	0				

The Biomedical Technology group had the highest mean SCT score as well as the highest minimum score in the whole sample. The Analytical Chemistry group achieved the second highest mean SCT score. The Pre–Technician scored the third highest followed by the Radiography group. The latter two groups had almost the same mean SCT score. The lowest scoring group of the sample was the Environmental Health.

The mean SCT scores indicate that the Biomedical Technology achieved the highest scores in the SCT.

The SD values recorded for the SCT ranged between 2.73 – 3.90. The SD values recorded for the WMS and the SA were much higher at 5.57 – 14.74 for the WMS and 7.97 – 16.51 for SA.

The SD-values obtained indicated that the SCT scores were not spreaded very wide, whilst the opposite is true of the WMS and SA where very high SD-values were recorded.

5.2.12 Mean SCT score for the advantaged/disadvantaged groups

5.2.12.1 Mean SCT scores

The test takers within each course group were divided according to their educational backgrounds: advantaged and disadvantaged groups. The mean SCT score and SD for the three variables SCT, WMS and SA were calculated separately for the two groups within their courses. This was done to examine the performance of the two groups within their course groups.

In each course group the advantaged scored higher than the disadvantaged.

It was noted that for the Analytical Chemistry and Pre–Technician groups, the difference in mean SCT score between the advantaged and disadvantaged groups, was 1 and 1.5 respectively. The test scores for the advantaged and disadvantaged did not differ much. For the Biomedical Technology and Radiography there was a marked difference in test scores between the advantaged and disadvantaged groups. For the Biomedical Technology group this difference was 3.3 and for the Radiography it was 3.6.

5.2.12.2 Standard deviation

The highest SD for SCT was recorded for the disadvantaged group in Radiography at 4.85 and second highest was for the Environmental Health group. It should be noted that in all instances the disadvantaged had a higher SD value for SCT than the advantaged, except for the Analytical Chemistry.

The SD values recorded for both WMS and SA were in all instances far greater than those for SCT.

Table 5.12 Mean SCT score and SD for advantaged/disadvantaged groups

Course group	SCHOOL		SCT	WMS	SA
Anal Chem	Advantaged	Mean	17.4	46.3	59.7
		N	8	8	8
		SD	3.5	7.8	10.8
	Disadvantaged	Mean	16.5	45.0	44.2
		N	15	15	15
		SD	2.8	4.2	13.9
	Total	Mean	16.8	45.4	49.6
		N	23	23	23
		SD	3	5.6	14.7
Biomed Tech	Advantaged	Mean	20.0	44.4	70.2
		N	5	5	5
		SD	2.5	15.6	14.3
	Disadvantaged	Mean	16.7	38.0	52.8
		N	10	9	10
		SD	2.8	6.9	14.9
	Total	Mean	17.8	40.3	58.6
		N	15	14	15
		SD	3.1	10.7	16.5
Env Health	Disadvantaged	Mean	12.5		58
		N	33		33
		SD	3.6		8
	Total	Mean	12.5		58
		N	33		33
		SD	3.6		8
Pre-Tech	Advantaged	Mean	15.5	52.8	47.7
		N	10	10	10
		SD	2.5	8.5	17.4
	Disadvantaged	Mean	14.1	46.1	48
		N	75	69	44
		SD	2.7	9.3	8
	Total	Mean	14.3	47	47.9
		N	85	79	54
		SD	2.7	9.4	10.1
Radiography	Advantaged	Mean	16.5	52.0	
		N	8	7	
		SD	1.9	15.5	
	Disadvantaged	Mean	12.9	59.2	
		N	14	13	
		SD	4.2	14.3	
	Total	Mean	14.2	56.7	
		N	22	20	
		SD	3.9	14.7	

5.2.12.3 Statistical difference between mean SCT scores for advantaged/disadvantaged

The Table 5.12 shows a difference in the mean SCT scores for the advantaged and disadvantaged groups. In order to determine whether this difference was statistically significant a t-Test was carried out. Table 5.13 shows the results of the t-Test.

Table 5.13 t-Test results for difference in SCT scores between advantaged/disadvantaged groups

Course group			t-test for equality of means		
			t	Df	Sig. (2-tailed)
Anal Chem	WMS	Equal variances assumed	.503	21	.620
	SCT	Equal variances Assumed	.687	21	.50
Biomed Tech	WMS	Equal variances assumed	1.079	12	.302
	SCT	Equal variances Assumed	2.239	13	.043*
Pre-Tech	WMS	Equal variances assumed	2.149	77	.035*
	SCT	Equal variances assumed	1.545	83	.126
Radiography	WMS	Equal variances assumed	-1.037	18	.313
	SCT	Equal variances Assumed	2.317	20	.031*

* Significant at 0.05 level

The above table indicates that the difference in mean SCT score between the two groups is significant at the 0.05 level for Biomedical Technology and Radiography, as well as for WMS for the Pre–Technician group.

5.2.13 Home language per course group

Table 5.14 gives a breakdown of the home languages of the test takers per course group.

Table 5.14 Home language as per course group

	Language					
	Unknown	A	E	Setswana	SS	X
Analytical Chemistry		2	5		1	15
Biomedical Technology	1	8	4			2
Environmental Health				33		
Pre-Technician		13	9	1	3	60
Radiography		11	3			8
Total	1	34	21	34	4	85

The Biomedical Technology and Radiography groups had more English and Afrikaans speakers than African language speakers.

The Analytical Chemistry and Pre–Technician groups had a higher percentage African language speakers than English and Afrikaans speakers combined.

The Environmental Health had Setswana speakers only.

The mean SCT score and SD were calculated as per home language to determine the effect of home language on test scores. Table 5.15 shows the mean SCT scores and SD for the SCT as per home language.

Table 5.15 Mean SCT scores and SD as per home language

	N	Mean	SD
Afrikaans	34	15.6	3.7
English	21	16.2	2.4
Xhosa	85	14.4	3.2
SS	4	16	2.8
Setswana	34	12.5	3.6
Total	178	14.5	3.5

This table shows that English speakers scored the highest mean, followed by the four South Sotho speakers. The Afrikaans speakers followed and thereafter the Xhosa and Setswana speakers.

The above table shows a clear difference in test scores amongst the different home language groups. In order to determine whether this difference was statistically significant the Anova test was performed. The results are shown in Table 5.16.

Table 5.16 Difference in SCT between home languages

ANOVA

SCIENCE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	246.965	4	61.741	5.695	.000
Within Groups	1875.445	173	10.841		
Total	2122.410	177			

The significant p-value of 0.0 indicates that the difference in test scores amongst the various language groups is statistically significant.

5.2.14 Correlation between SCT, WMS and SA

A Pearson correlation was performed between the predictor variables, SCT and WMS, and the criterion SA to determine whether they were able to predict the criterion. This was done separately for each course. Table 5.17 contains the results of this computation.

Table 5.17 Pearson correlation between SCT, WMS and SA

Correlations

Course group			SCIENCE	WMS	SA1
Anal Chem	SCIENCE	Pearson Correlation	1.000	.276	.330
		Sig. (2-tailed)	.	.202	.124
		N	23	23	23
	WMS	Pearson Correlation	.276	1.000	.185
		Sig. (2-tailed)	.202	.	.399
		N	23	23	23
	SA1	Pearson Correlation	.330	.185	1.000
		Sig. (2-tailed)	.124	.399	.
		N	23	23	23
Biomed Tech	SCIENCE	Pearson Correlation	1.000	.054	.361
		Sig. (2-tailed)	.	.855	.186
		N	15	14	15
	WMS	Pearson Correlation	.054	1.000	.575*
		Sig. (2-tailed)	.855	.	.031
		N	14	14	14
	SA1	Pearson Correlation	.361	.575*	1.000
		Sig. (2-tailed)	.186	.031	.
		N	15	14	15
Env Health	SCIENCE	Pearson Correlation	1.000	.[a]	.432*
		Sig. (2-tailed)	.	.	.012
		N	33	0	33
	WMS	Pearson Correlation	.[a]	.[a]	.[a]
		Sig. (2-tailed)	.	.	.
		N	0	0	0
	SA1	Pearson Correlation	.432*	.[a]	1.000
		Sig. (2-tailed)	.012	.	.
		N	33	0	33
Pre-Tech	SCIENCE	Pearson Correlation	1.000	.076	.063
		Sig. (2-tailed)	.	.504	.650
		N	86	80	54
	WMS	Pearson Correlation	.076	1.000	.251
		Sig. (2-tailed)	.504	.	.069
		N	80	80	53
	SA1	Pearson Correlation	.063	.251	1.000
		Sig. (2-tailed)	.650	.069	.
		N	54	53	54
Radiography	SCIENCE	Pearson Correlation	1.000	.175	.[a]
		Sig. (2-tailed)	.	.460	.
		N	22	20	0
	WMS	Pearson Correlation	.175	1.000	.[a]
		Sig. (2-tailed)	.460	.	.
		N	20	20	0
	SA1	Pearson Correlation	.[a]	.[a]	.[a]
		Sig. (2-tailed)	.	.	.
		N	0	0	0

*. Correlation is significant at the 0.05 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

For the course groups, Biomedical Technology and Pre–Technician, the WMS was a better predictor than the SCT. In the case of the Biomedical Technology group a p–value of 0.031 was achieved between WMS and SA, and for the Pre–Technician group a p–value of 0.069 was recorded.

The SCT generated a better p–value than WMS for the Analytical Chemistry group, whilst for the Environmental Health group it showed a significant p–value of 0.012.

There were no SA values for the Radiography group, hence no correlation was carried out for this group.

There was also no significant correlation between SCT and WMS in any course group, which means that they were independent variables.

No negative correlations between any of the variables were found.

5.2.15 Multiple regression analysis

The Pearson correlation between the variables SCT, WMS and SA showed no correlation between ST and WMS. This is a favourable result as it means that the two variables are independent measures that are mutually exclusive.

The regression analysis was performed to determine if a combination of the SCT and WMS would be a better predictor of SA. The regression was also performed to determine which of the two variables, SCT or WMS, is the better predictor of SA.

Regression analysis was performed for Analytical Chemistry, Biomedical Technology and Pre–Technician groups only. This could not be done for Environmental Health and Radiography groups due to either the WMS or SA mark being unavailable at the time.

For each group there is a Model Summary, Anova and Coefficients table. The Model Summary gives the correlation (r- value) and variance (r^2–value that explains the variance in the criterion score) for the combined variables SCT and WMS. The Anova shows the overall significance (p–value) or ability of the two variables combined, to predict the SA score,

whilst the Coefficients table explains the individual contribution of the predictor variables towards the SA score by means of the Beta–value and a significant p-value. The Beta-value is a measure of the strength of the relation between the predictor variable and criterion.

The next few tables show the Stepwise method multiple regression analysis for the courses mentioned.

5.2.15.1 Analytical Chemistry

The regression tables for this course group are given next.

Table 5.18.1 Analytical Chemistry: Model Summary

Course	R	r^2	Adjusted r^2	Std. Error of the estimate
Analytical Chemistry	.344	.118	.03	14.47

Predictors: SCT, WMS

Table 5.18.1 shows that when the combined SCT and WMS were correlated with the SA, the correlation, r-value obtained was better than in Table 5.17. This indicates that the combined SCT and WMS give a better correlation than separately.

The r^2–value indicates that together the SCT and WMS accounted for only 11.8% of the SA score, meaning that 88.2% was accounted for by other factors.

Table 5.18.2 Analytical Chemistry: Anova results

Course	Sum of squares	df	Mean Square	F	Sig.
Analytical Chemistry	561.58	2	280.79	1.34	.28

Predictors: SCT, WMS

Dependent: SA

The Anova test generated a significant value of 0.28, meaning that the SCT and WMS combined, did not predict the SA score, or did not contribute significantly to the SA score.

Table 5.18.3 Analytical Chemistry: Coefficient results

Course	Model	Standardised Coefficients	Sig
		Beta	
Analytical Chemistry	Constant		.655
	WMS	.101	.648
	SCT	.302	.182

Dependent variable: SA

The Coefficient table explains the individual contribution of the SCT or WMS to the SA score by means of a Beta-value. The Beta-value for SCT was slightly higher than for WMS, indicating that the SCT contributed more towards the SA score. The SCT was a better predictor or a more significant predictor than the WMS for the Analytical Chemistry group. This confirms the result of the Pearson correlation in Table 5.17.

5.2.15.2 Biomedical Technology

The regression tables for this group are given next.

Table 5.19.1 Biomedical Technology: Model Summary

Course	R	r^2	Adjusted r^2	Std. Error of the estimate
Biomedical Technology	.626	.392	.281	12.41

Predictors: SCT, WMS

The Pearson correlation obtained between SCT and SA in Table 5.17 was 0.575. The multiple regression for the combined SCT and WMS variables yielded a better correlation of 0.626 (Table 5.19.1).

The r^2-value was 0.392, meaning that together these two variables explained 39.2% of the SA score, implying that 60.8% of the SA score was explained by other factors.

Table 5.19.2 Biomedical Technology: Anova results

Course	Sum of squares	df	Mean Square	F	Sig.
Biomedical Technology	1092.40	2	546.20	3.55	.065

Predictors: SCT, WMS

Dependent variable: SA

The significant value > 0.065 indicates that together the two predictor variables did not contribute significantly to the SA score.

Table 5.19.3 Biomedical Technology: Coefficient results

Course	Model	Standardised Coefficients	Sig.
		Beta	
Biomedical Technology	Constant		.725
	WMS	.562	.036
	SCT	.247	.316

Dependent variable: SA

A higher Beta-value was obtained for WMS, which means that the WMS contributed more towards the SA score than did the SCT. This can be seen from the better significant value recorded for WMS. The significant p-value between WMS and SA gave a similar indication in Table 5.17.

5.2.15.3 Pre-Technician

The results of the regression analysis for this group are shown in the following tables.

Table 5.20.1 Pre-Technician: Model Summary

Course	r	r^2	Adjusted r^2	Std. Error of the estimate
Pre-Technician	.251	.063	.026	10.08

Predictors: SCT, WMS

The Pearson correlation between SCT and SA yielded a value of 0.063 (see Table 5.17). As can be seen in Table 5.20.1 the correlation for the combined variables SCT and WMS yielded a better correlation of 0.251.

The r^2- value indicates that together the two variables of SCT and WMS only contributed 6.3% towards the SA score.

Table 5.20.2 Pre-Technician: Anova results

Course	Sum of squares	df	Mean Square	F	Sig.
Pre-Technician	343.02	2	171.51	1.69	.195

Predictors: SCT, WMS

Dependent variable: SA

The significant value shown in Table 5.20.2 shows that the correlation between the combined variables SCT and WMS and the criterion SA was not a significant one and confirmed the poor correspondence between the predictor variables and the criterion (Table 5.20.1).

Table 5.20.3 Pre-Technician: Coefficient results

Course	Model	Standardised Coefficients	Sig.
		Beta	
Pre-Technician	Constant		.002
	WMS	.253	.081
	SCT	-.007	.962

Dependent variable: SA

The Coefficient table indicates the contribution that each variable made to the SA score. The Beta-value for WMS was higher than for SCT, indicating that it contributed more towards the SA score. The relationship was confirmed by the lower p-value recorded for WMS. This reaffirmed the results of the Pearson correlation between WMS and SA in Table 5.17. The results show that the SCT corresponded inversely with the SA score.

5.2.16 Cut-off score

A possible cut-off score beyond which students should not be selected was determined. Table 5.21 reflects how many pass, fail or had no results, according to the SA mark, there were for each score category.

The pass % for each test score band was calculated and is reflected in Table 5.21. The table shows that the success rates of the students in the 20+ - band was 75% compared to the 37% - 47% pass rate of the other bands. The suggested cut-off score for the SCT is therefore 20.

Table 5.21 SCT score grading

	Science Competency Test Score					
	0-4	5-9	10-14	15-19	20+	Total
No Result	1	3	26	26	2	58
Pass		6	36	27	12	81
Fail		4	15	19	2	40
Total	1	13	77	72	16	179
Pass %		46%	47%	37%	75%	

The large number of cases for which there were no pass/fail result (bands 10 – 14 and 15 – 19), disabled the calculation of those eligible for the Extended or Pre-Technician programmes. However, the high pass rate of those in the 20+ - band, is a clear indication that they should be considered for the Normal programme.

5.3 SUMMARY AND INTERPRETATION OF RESULTS

There were no SA values available for the Radiography group and the Environmental Health group had no WMS mark. This hampered the thorough assessment of the Science Competency Test's performance as a testing instrument. The performance of the Science Competency Test as a testing instrument as shown by the statistical results is summarised next.

5.3.1 Performance in subsections of the Science Competency Test

The higher scoring group performed satisfactory in the content and skills sections. However, they scored only a 50% median in the experimental work section.

The lower scoring group did badly in all the sections. The best median subscore for this group was a low 40% in the skills section.

5.3.2 Performance of test items

Despite the good p-values of the majority of the items, there were too many with unsatisfactory discrimination indices. Discrimination indices are used primarily to identify defective items and the items that do not discriminate sharply should be revised or excluded from the Science Competency Test.

Too few items (9 out of 30) had item difficulty indices around 0.5, (i.e. between 0.45 – 0.55). The remaining 21 items need to be revised, as some were either too difficult or too easy.

Insufficient items (6 out of 30) had satisfactory p-values, discrimination indices and item difficulty values simultaneously. Statistically, it means that only six items were good items.

The above contributed to the test not being discriminating enough and was a possible reason for the low SD values and predictive power obtained for it.

5.3.3 Mean SCT score and standard deviation

5.3.3.1 Mean SCT score

The high mean SCT score of Biomedical Technology can be attributed to the 80% Afrikaans or English speakers and the 33.3% advantaged students who constituted this group.

Likewise, the low mean SCT scores of the Environmental Health can be attributed to its 100% disadvantaged status.

5.3.3.1.1 Advantaged/disadvantaged groups

A comparison of the mean SCT scores between the advantaged and disadvantaged groups supports the tendency of the influence of educational background on Science Competency Test scores. The performance of the advantaged was noticeably better throughout.

The difference in the mean SCT scores of the advantaged and disadvantaged groups for the Analytical Chemistry and Pre–Technician groups was far less than those recorded for the Biomedical Technology and Radiography. The reason for this difference seems to be the high percentage of English and Afrikaans speakers within the Biomedical Technology and Radiography groups.

An interesting point is that the disadvantaged groups of Biomedical Technology and Analytical Chemistry were fairly high scorers – these two sets of disadvantaged achieved mean SCT scores of 16.7 and 16.5 respectively. The disadvantaged of the other course groups has mean scores of between 12.48–14.1. The fact that they were high scorers did not improve the predictive power of the Science Competency Test, but it seems that the greater the difference in scores between the advantaged/disadvantaged within a course group, the better the correlations.

The highest variance recorded for the combined SCT and WMS was 39.2% for Biomedical Technology.

5.3.3.2 Standard deviation

The low SD values for Science Competency Test are an indication that the Science Competency Test was not discriminating and that most of the students scored the same mark. This could be because the items did not discriminate between the high and low scorers. Higher SD values would have produced favourable result.

The comparatively high SD for Science Competency Test for the Environmental Health group coincided with a good p–value of 0.012 between Science Competency Test and SA. The

Radiography group had a similar SD value. Unfortunately, a p-value between SA and Science Competency Test could not be calculated since this group did not have a SA mark.

In contrast to the above, both the WMS and SA generated large SD–values which seem to indicate that they discriminated over a wide range of ability.

5.3.4 Reliability of Science Competency Test

The Cronbach Alpha reliability coefficients are evidence of the internal consistency of the test. The values obtained for all course groups, except Environmental Health, were very low and indicative of an overall low internal consistency of the Science Competency Test. The moderate value for the whole sample endorsed the results.

The Science Competency Test showed a fair reliability for Environmental Health.

5.3.5 Home language and educational background

The English speakers in the sample came from good schools and some of the Afrikaans speakers enjoyed an advantaged school background as well. All of the African language speakers were from disadvantaged school backgrounds.

The results showed that the Afrikaans and English speakers were the high scorers. This, and the fact that the disadvantaged in all the course groups scored less in the Science Competency Test than their counterparts, tends to prove that home language and the educational background of the test takers affect the Science Competency Test scores.

5.3.6 Correlation between SCT, WMS and SA

The SCT showed a significance at the 5% level for the Environmental Health group only.

The WMS predictor variable was significant at the 5% level for Biomedical Technology.

5.3.7 Regression

A combination of the variables, SCT and WMS, was better able to predict the SA score. Higher correlation figures were generated for the three groups Analytical Chemistry, Biomedical Technology and Pre-Technician. This supports the fact that the SCT should be used in conjunction with other variables and not on its own.

The Enter method used in the regression analyses reaffirmed that the SCT was a predictor of SA for the Environmental Health group at the 5% level. The regression further reaffirmed the significance at the 5% level of the WMS for BiomedicalTechnology.

However, the significance of the all correlations and predictions was generally low.

5.4 CONCLUSION

When compared to the performance of the WMS, the Science Competency Test was not more successful in predicting SA scores. Both were able to predict for one course group only.

The various correlations obtained for the Environmental Health group were steady and satisfactory throughout. Possible explanations for its performance with this group specifically are two-fold. This group differed from the other course groups in that it had a consistent school background, whilst the influence of educational background on the Science Competency Test scores prevailed in the other groups. This group was also homogenous in terms of being entirely disadvantaged, all spoke the same home language (with the result that the influences of other languages were absent), the same subjects and the same number of subjects were offered by all in the first semester (with the results that the SA score was a uniform and valid measurement for this group) and everyone followed the extended programme.

A discussion of the findings of this research is given in the next chapter.

CHAPTER SIX

RECOMMENDATIONS AND CONCLUSIONS

6.1 INTRODUCTION

A summary of the research process in terms of the methodology used, problems encountered, confirmation of existing knowledge, gaining of new knowledge and recommendations for future efforts are discussed in this chapter. The chapter concludes with the main conclusions drawn from the results and findings of the research.

6.2 RECOMMENDATIONS

Various important issues regarding the research findings are discussed.

6.2.1 An account of the methodology

6.2.1.1 Pilot testing

The item try–outs were done according to the test–retest method. As was explained previously this method was not the ideal one to use. The Grade 12 year is not the best year in which to do any item try–outs since the learners are receiving intensive teaching and testing throughout the year. The maturity of the test taker further impacts on the test scores. This sustained preparation for their final examinations is in stark contrast to the period that precedes the entry-level writing which is marked by a total lack of contact with school and subject content. An alternative method in which the maturity of the test taker does not play a role should be considered.

The ideal period in which to do the item try-outs needs to be well planned. Ideally a period straight after a recess, but also after the necessary content had been covered in school, should suffice. A decision to cover mostly Grade 11 content and only part of the Grade 12

content will facillitate pilot testing much earlier in the Grade 12 year. An option could be to use the entire Grade 11 physical science syllabus and not just the sections that are examinable at the end of the Grade 12 year.

6.2.1.2 The number of items in the Science Competency Test

The Science Competency Test tested three definite and separate areas of science. With only 30 items the subareas at 12, 10 and 8 items each were very small. Very little information could be gained from the sub-totals. An increase in the number of items (to at least 45) will offer a number of advantages.

An increase in the number of items per subarea will render the subscores more useful in terms of achievement of knowledge of content, mastery of skills and practical work. With more items per subarea, the domain of the test will broaden. This in turn will allow a fair assessment of the areas that need further preparation and will facilitate the design and update of an educational support programme.

6.2.1.3 The item selection process

The development process was guided by the test's ultimate purpose of the identification of preparedness. In addition to this, the Science Competency Test was designed to test a wide range of difficulty, have three sections each of a specific weight and have each item at a specified degree of difficulty.

These conditions restricted the entire item selection process. In order to best meet all the conditions, the items with better statistical data were at times excluded. If the items with the best statistical data were selected every time an entirely different test would have ensued which would perhaps have performed differently.

Fewer conditions will be less restrictive. For this reason, the less crucial conditions should be overlooked. The condition of testing over a wide range of ability is unnecessary, since the Grade 12 results do predict for the advantaged. The problem area is the lower ability or

those who do not meet the entrance requirement. Therefore, the Science Competency Test should concentrate on this ability range.

6.2.1.4 Improvement of the test items

In general, the accuracy and clarity of the items can be enhanced by rephrasing them and by using more suitable terminology. A few examples are given:

Item 1: Replace ‘unit’ with the more correct ‘SI-unit’ (in Item 7 as well), and substitute ‘gravity’ with ‘gravitational acceleration’.

Item 2: The wording should be changed to indicate that the bulbs are to be connected in series.

Item 5: The unit of work done is ‘joule’ and not ‘Joules’.

Item 8: The wording of the options does not fit into the main question. Change the wording of either the main question or those of the options.

Item 15: Add a sentence that states the slope is identical in all the options.

6.2.1.5 Practical component

The present study did not explore the possibility of a practical component to the Science Competency Test. Whilst this remains an option, results showed that the items on practical work were answered poorly.

6.2.1.6 Questionnaire

The use of the questionnaire to gather information about the core competencies needed to succeed in the first year, elicited a good response. However, the ultimate response remains a hundred percent return.

6.2.1.7 Weighted matric score

The WMS system used by PET is not reliable since many candidates were admitted who did not meet the required WMS. Some applicants had WMS far below the minimum score. The Environmental Health group hailed from Botswana and did not have the South African Grade 12 results. The entire group was placed in the extended programme.

The correlations using WMS are therefore not really possible.

6.2.1.8 The semester average mark

The SA mark was calculated as the average first semester examination mark out of the maximum number of subjects that the student was suppose to do in a specific programme. There were several reasons for this.

The number of subjects offered by students in the same course group varied. Students in the Analytical Chemistry followed two different programmes, namely the Normal and Extended programmes. Those in the normal programme did five subjects and those in the extended programme did three subjects. The SA was calculated by dividing by three for those in the extended programme and by dividing by five for those in the normal programme.

Some students offered less subjects than what was required they do. In these cases, the number of subjects they were supposed to do was used to calculate the SA mark. This was done because students doing fewer subjects generally do better in their subjects and would consequently score a higher average mark than those doing more subjects, even though it is far better to pass all the required subjects in your first semester than only the subminimum.

Despite these precautionary measures the SA was not a uniform measure within the same group.

Another problem that also impacted on the validity of the SA was that some courses require their students to do more subjects than other courses and promotion rules were different for the each course.

Furthermore, the courses are not of the same degree of difficulty. This means that the criterion that was calculated for a specific course group, namely the SA, cannot be compared amongst the different courses. For example a 50% SA for Analytical Chemistry is not equivalent to a 50% SA for Pre–Technician Programme or Environmental Health, but perhaps equivalent to a 60%.

On the strength of the points raised, the conclusions based on correlations between SCT scores and SA are perhaps not accurate indications of the performance of the Science Competency Test.

6.2.2 Support of literature

6.2.2.1 Multiple indicators of success

The Science Competency Test measured preparedness in the Environmental Health group at the 5%-level. This measurement can be substantiated as well as improved by using a combination of indicators of academic success.

The literature has shown that prediction is improved by using multiple indicators of success Huddle et al (1999), Miller (1992), Rutherford & Watson (1990), Van der Merwe (2000), van Rooyen (2001) and Zaaiman (1996). It is therefore suggested that a combination of suitable indicators be implemented, together with the Science Competency Test, to improve the reliability, validity and predictive power of the measurement.

Various indicators, not necessarily academic, could be considered (Huysamen 1996, van Eeden et al 2001, van Rooyen 2001). All the cohorts concerning a student's development and that would aid the selection and admission of the student who will benefit from education should be used. Possible indicators are the availability of a bursary, residence of student, personality factors to name a few.

Since the same variables do not predict for all demographic groups (Grade 12 results do not predict for the disadvantaged), one consideration could be to have different predictor variables for different groups.

6.2.2.2 The performance of Science Competency Test within a test battery

On its own the Science Competency Test did not predict significantly at the 1% level for any group. It would be useful to assess its performance within a test battery, as one of the purposes of the Science Competency Test was that it would be used as part of a test battery.

Such an assessment could show that the performance of the Science Competency Test compares with the performances of the other tests in the battery. In other words, it could show that those who did poorly in the Science Competency Test also did poorly in the test battery, and thereby validate that the Science Competency Test does not discriminate against any group. It could also show that the Science Competency Test improves the prediction of the test battery measurement. Alternatively, the assessment of its performance within a test battery could verify the findings of this research.

6.2.2.3 Identifying preparedness

This study attempted to identify preparedness as opposed to the measurement of potential for change or potential to learn as studied by Griesel (1992), Miller (1992) and Yeld & Haeck (1997). It failed to do so by means of its list of core competencies.

The question is whether one should abandon testing for preparedness in favour of the TTT method. The response to this tends to be negative since the results have shown that skills items generated a competitive response from both groups (see Table 5.9). This lends support to the notion that testing may still work if the correct type of item is used.

An encouraging factor was that the respondents to the questionnaire rated the skills section almost as important as the content section. According to the rating, skills are valuable and useful and perhaps not as inconsequential as the assessment of, for example spatial ability in content–free testing. The preparedness of the students could then be measured by a test that consists of more skills than content items.

6.2.2.4 Content/content-free tests

This research sought a middle path on the issue of the use of content in entry–level tests. The Science Competency Test did not contain only content. The weight thereof was sanctioned by the outcome of the questionnaires.

The response of the disadvantaged to the content items was discouraging. A reduction of the number of content items is suggested. Since content items do have a role to play in improving the predictive power of the measurement (Rutherford 1992), the suggestion is not to exclude them totally, especially since the total exclusion of content in a Science Competency Test is incomprehensible due to the subject-specific nature of science.

Both groups answered the practical work items poorly. An increase in the number of these items would not serve any purpose.

The number of skills items should be increased. These items contain very limited amount of content and were answered very encouragingly by the disadvantaged group, and best by the advantaged group. Items about general skills and experimental skills thus provide an alternative for content and practical items. An entry–level test of mostly, or only, general and experimental skills items would be a better option to consider in future.

The above corroborates the opinions of Shochet (1994) and Yeld & Haeck (1994), that testing for content in an entry-level test to be administered to disadvantaged does not generate the desired information.

6.2.2.5 Weight of subsections

The weight of content, skill and practical work in the Science Competency Test was prescribed by the outcome of the questionnaires. However, this study showed that the ratio of content, skills and practical work items as suggested by the outcome of the questionnaire was not ideal.

The outcome of this study suggests that the number of skills items should be increased and fewer content items be included. The practical work items should perhaps remain unaltered, or be omitted entirely as this subsection was not very discriminating.

This is in agreement with Altink (1987) that a predictive test should lie halfway between an achievement and a content–free (ability/IQ) test.

6.2.2.6 Factors that influence academic performance

This study was based on the theoretical framework that academic performance is determined by innate ability and the life experiences of the individual and that it can be improved through education and training.

This research has shown that the performance of a group was affected by the different curriculae they followed. The lowest mean SCT score recorded for this group could be due to the lack of exposure to the syllabus that was tested in the Science Competency Test. Alternatively, those with prior knowledge performed better in the Science Competency Test.

6.3 VALUE OF THIS STUDY

Although the Science Competency Test failed to predict significantly for the whole sample, the findings of this study can assist with the design and refinement of subsequent science entry–level tests.

This study highlighted the weight of each section in an entry-level test and showed how well or poorly each section was answered. The Science Competency Test posed items at specific intellectual levels. The items not only tested for a specific skill or content, but also did so at a specific degree of difficulty.

First year lecturers validated a list of skills and knowledge which can be applied in further studies.

An attempt to design a test with too many purposes complicates the main issues. The study suggested that it would be better to concentrate on identifying preparedness in the lower achiever group than for a wide range of the ability spectrum.

The study showed that a single variable should not be used to assess preparedness. It showed that when two variables, the SCT and WMS, were used the reliability correlation improved.

The finding that the disadvantaged group was able to compete with the advantaged group in the skills item section is invaluable to future entry–level test development.

This study proved that the disadvantaged lack knowledge of content and that both groups were not satisfactorily exposed to practical or laboratory work.

6.4 MAIN FINDINGS AND CONCLUSIONS

The measurement of preparedness in the disadvantaged remains unresolved.

6.4.1 Support of literature

In South Africa, home language and educational background are closely associated: Africans speak an African language and the majority are disadvantaged.

Similarly to the studies conducted by Altink (1987), Brown (1983), Griesel (1992), Huysamen (1997), Miller (1992), Rutherford (1992), van Eeden et al (2001) and Yeld and Haeck (1997) this study has shown that English speakers perform better in entry–level tests than do Afrikaans speakers or Africans, and that students who enjoyed a good schooling, fared better in entry–level tests. In short, it has showed that the advantaged performed better than the disadvantaged.

This study also confirmed the findings of Botha (2000), Botha & Cilliers (1999), van der Merwe (2000) and van Rooyen (2001) that the Grade 12 results are not a significant predictor of future academic performance.

The general lack of subject content knowledge by the disadvantaged and exposure to laboratory work by both groups, but more so the disadvantaged, were highlighted by this study. This is also in accordance with the manifestations of disadvantaged as recorded by Miller (1997) and Fourie & Naude-de Jager (1992).

This study proved by means of an entire group, namely the Environmental Health group, that when learners do not enjoy similar schooling, their academic performance suffers as was reported by Zaaiman et al (1998).

6.4.2 Efficacy of Science Competency Test as a testing instrument

The aim of the research to develop a science entry-level test that would measure the preparedness in especially the disadvantaged was not achieved.

The hypothesis remains unresolved since the results are inconclusive. Further research and perhaps a different methodology need to be explored.

Due to the outcome of the research the notion of a Compensatory Model cannot be pursued. The categorisation of students into three groups of those who should enter mainstream, or the extended programme or denied access cannot be concluded either. These issues remain open for exploration by future research efforts.

6.4.3 Fairness in testing procedure

Fairness in testing should be a moral obligation of the test developer and user alike. The decisions that are made on the basis of test scores can only be just and fair if the measuring instrument allowed all test takers an equal opportunity to do well. Fair decisions are crucial to South Africans especially in the light of the inequities of apartheid, but more so for the future of the country and in support of the transformations in education.

It should be noted that all items were piloted in disadvantaged schools and that the items in the Science Competency Test were selected from the pool of items that were piloted in these same school schools. However, this did not improve the predictability of the Science Competency Test or removed the phenomenon of differential performance of the advantaged and disadvantaged groups.

A difference in test performance between the different language groups and amongst those with dissimilar educational experiences was noted in the study. One should, therefore, take this into account when interpreting the results. A correction factor could be introduced to remove any bias.

The use of content in the Science Competency Test benefited the advantaged group. A test with less content would be better and fairer to the disadvantaged.

Since fairness in testing refers also to the use of the test, the Science Competency Test should not be used as the sole criterion for selection, but rather, in conjunction with other data about the student.

6.5 LAST WORD

The difference in academic performance between racial, ethnic, cultural and/or socio–economic subgroups is prevalent and well-known worldwide (Huysamen & Raubenheimer 1999).

When we compare South African progress in the field of entry-level testing to that of first world countries that are still struggling with this problem after many decades, one realises that we have come a long way in a short space of time, especially taking into consideration our economic and political strife, lack of resources, internal socio–political problems and Third World status.

In South Africa, the aforementioned are all the areas that should ideally be transformed, along with education. The ultimate aim of testing ought to be the elimination of the differences in educational opportunities that exist between subgroups of a population.

In order to eradicate the problem of identification of preparedness fully in the disadvantaged, the solution lies in the transformation of education from Grade 1 and throughout schooling in terms of equal provisions and opportunities. The introduction of English at least as a second language, into all schools should also occur as early as Grade 1 since this is the language of instruction at most tertiary institutions (Asmal 2002, van Eeden et al 2001). In addition to this, some tertiary institutions should offer instruction in the vernacular of the area in which they are situated (Asmal 2002).

In time, an education system should evolve that will ensure the actualisation of academic achievement that reflects the true potential of the student. Once this is achieved, the need for the measurement of preparedness in the disadvantaged will become obsolete. In the interim, educational support programmes will become the norm whilst they serve to rectify the imbalances.

REFERENCES

Ahmann, J.S. (1962). Testing Student Achievement and Aptitudes. Washington, D.C. The Centre for Applied Research in Education.

Ahmann, J.S. & Glock, M.D. (1971). Measuring and Evaluating Educational Achievement. Boston. Allyn & Bacon.

Altink, W.M.M. (1987). The Evaluation of Selection Tests for Educational Upgrading Programmes in Botswana and Swaziland. International Journal of Educational Development. 7(1). pp.1 - 12.

Anastasi, A. (1982). Psychological Testing. 5th ed. New York. Macmillan.

Asmal, K. (2002 November 5). African-language varsity envisioned. The Herald. p.2.

Badsha, N. (1992). Some Perspectives from Historically African Institutions on the realties of Selection and Admissions. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 19 - 37).

Ball, R. & Archer, G. (1991). Understanding Science Assignments. Communication and IT skills. London. Cambridge University Press.

Bawa, A. (1993). Academic Development in Science and Technology Education. Bringing Students up to scratch. SAAAD News. 1 September. Vol.1No.1. pp. 10 – 11.

Bengu, S. (1995). Turning The Battlegrounds into Places of Learning. In Tait, A. (Ed.). (1995). Portfolio of South Africa, 1995. (pp. 88 - 91). Gauteng. South Africa. Portfolio Business Publications.

Botha, H.L. (2000). Access Tests at the University of Stellenbosch: A Process to Widen Access and Ensure Success. National Conference on access with success into Further and Higher Education. University of the Orange Free State. 25 - 26 May.

Botha, H.L. & Cilliers, C.D. (1999). Preparedness for university study: designing a thinking skills test. South African Journal of Higher Education. 13(1). pp. 144 - 152.

Boyd, J.; Whitelaw, W. & Warren, P. (1991a). Understanding Science. Teacher's Resource Book. London. John Murray.

Boyd, J.; Whitelaw, W. & Warren, P. (1991b). Understanding Science 2. London. John Murray.

Boyd, J.; Whitelaw, W. & Warren, P. (1991c). Understanding Science 3. London. John Murray.

Brown, F.G. (1983). Principles of Educational and Psychological Testing.3rd ed. Wisconsin. Holt, Rinehart & Winston.

Calitz, A.P. (1984). Evaluation of the Aptitudes of Prospective Computer Science Students. Published 1997.Thesis Ph.D. University of Port Elizabeth. Port Elizabeth. South Africa.

Carter, C.S., LaRussa, M.A.& Bodner, G.M. (1987). A study of two measures of spatial ability as predictors of success in different levels General Chemistry. Journal of Research in Science Teaching. 24 (7). pp. 645 - 657.

Claassen, J.C. (1993). Affirmative action and its possible implementation in the South African education system. South African Journal of Education. 13(4). pp. 149 - 153.

Code of Fair Testing Practices in Education. (1998). Joint Committee on Testing Practices. Washington, D.C. [Brochure]

Craig, A.P. & Kernoff, R.J. (1995). Development of Textual Interpretation by Underprepared students. South African Journal of Higher Education. 9(1). pp. 23 - 30.

Cronbach, L.J. (1970). Essentials of Psychological Testing. 3rd ed. New York. Harper & Row.

Cunningham, G.K. (1986). Educational and Psychological Measurement. New York. Macmillan.

Department of Education and Science Welsh Office. (1985). GCSE General Certificate of Secondary Education. The National Criteria. Physics. London. Her Majesty's Stationery Office.

Department of Education and Science Welsh Office. (1985). GCSE General Certificate of Secondary Education. The National Criteria. Chemistry. London. Her Majesty's Stationery Office.

Ebel, R.L. (1972). Essentials of Educational Measurement. 2nd ed. Englewood Cliffs. N.J. Prentice-Hall.

File, J. (1992). An Overview of Access and Related Policy issues, with particular reference to the tension between excellence and equity. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 4 - 18).

Fourie, C.M. & Naude - de Jager, S.J. (1992). Die Identifisering van Risikostudente. South African Journal of Higher Education. 6(3). pp. 17 - 20.

Good, C.V. (1959). Dictionary of Education. 2nd Edition. New York. McGraw-Hill.

Griesel, H. (1992). A Developmental Selection Procedure. In Badsha,N.,Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 58 – 69).

Gronlund, N.E. (1968). Readings in Measurement and Evaluation. New York. Macmillan Company.

Gronlund, N.E. (1985). Measurement and Evaluation in Teaching. 5th ed. New York. Macmillan.

Haladyna, T.M. & Roid, G.H. (1982). A Technology for Test-item Writing. New York. Academic Press.

Helmstadter, G.C. (1964). Principles of Psychological Measurement. New York. Meredith Publishing Company.

Hill, G.C., Spiers, A.B., Tarrant, R.J. & Woods, G.T. (1969). Multiple choice question in Elementary Science. Book 1 Chemistry. London. Pergamon Press.

Huddle, P.A., Green, G.& White, M.D. (1999). Diagnostic Chemistry Test for Placement of Students in various Chemistry I courses at the University of the Witwatersrand (Wits). Proceedings 7th SAARMSE Conference. (pp. 180-185). Harare.

Huysamen, G.K. (1996). Fair and unbiased admission procedures for South African institutions of higher education. South African Journal of Higher Education. 10(2). pp. 199 – 207.

Huysamen, G.K. (1997). Potential Ramifications of Admissions Testing at South African institutions of Higher Education. South African Journal of Higher Education. 11(1). pp. 65 - 71.

Huysamen, G.K. (1999). Psychometric explanations for the poor predictability of the tertiary - academic performance of educationally disadvantaged students. South African Journal of Higher Education. 13(1). pp. 132 –138.

Huysamen, G.K. & Raubenheimer, J.E. (1999). Demographic - group differences in the prediction of tertiary - academic performance. South African Journal of Higher Education. 13(1). pp. 171 - 177.

Johns, L. (2001, May 27). National exams for key subjects. Sunday Tribune. p.8.

Jordaan, J.J. (1995). Affirmative action: excellence versus equity. South African Journal of Higher Education. 9(1). pp. 53 - 63.

Khotseng, B.M. (1992). Universities in post - apartheid South Africa. South African Journal of Higher Education. 6(2). pp. 88 - 93.

Koch, E., Foxcroft, C.& Watson, A.. (2001). A developmental focus to student access at the University of Port Elizabeth: process and preliminary insights in placement assessment. South African Journal of Higher Education. 15(2). pp. 126-131.

Kok, J.C. (1992). Application of Invitational Education in cases of at-risk learners. South African Journal of Higher Education. 12(1). pp. 87 - 91.

Krathwohl, D.R., Bloom, B.S. & Masia, B.B. (1956). Taxonomy of Educational Objectives. London. Longman.

Lindblom - Ylanne S., Lonka, K & Leskinen, E. (1996). Selecting students for medical school : What predicts success during basic science courses ? A cognitive approach. Higher Education. 31. pp. 507 - 527.

Lindeman, R.H. (1967). Educational Measurement. Illionois. Scott, Foresman and Company.

Lindquist, E.F. (1955). Educational Measurement. Wisconsin. George Banta Publishing Company.

Malala, J. (2000). Education. Portfolio on SA 1999/2000. (pp. 74-77). Gauteng, South Africa. Portfolio Business Publications.

Malatji, J.M. (1992). Some Perspectives from Historically African Institutions on the realties of Selection and Admissions. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 19 - 37).

Manamela, N.M. (1997). No, no, no Mr Principal and Vice Chancellor: change and adapt or perish. South African Journal of Higher Education. 11(2), pp. 58 - 62.

Mathews, J.C. (1975). Objective Tests in Modern Chemistry. London. Hutchinson Educational.

McCelland, D.C. (1973). Testing for Competence Rather Than for 'Intelligence'. The American Psychologist. Vol. 28. pp. 1 - 14.

McDuell, B. (1989). Examining GCSE Chemistry. Cheltenham. Stanley Thornes.

Mehl, M. (1992). An Overview of Access and Related Policy issues, with particular reference to the tension between excellence and equity. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 4 - 18).

Miller, R. (1992). Double, double, toil and trouble: the problem of student selection. SA Journal of Higher Education. 6 (1). pp. 98 - 104.

Miller, R. (1997). Mark my words, Part 2: Students. South African Journal of Higher Education. 11(1). pp.11-18.

Mitchell, T. (1989). What Do Instructors Expect from Beginning Chemistry Students? Journal of Chemical Education. 66(7). pp. 562 - 564.

National Commission on Higher Education. (1996). A Framework for Transformation. Higher Education: System . Governance .Funding.

Needham, G. (1989). GCSE Practical Assessment Physics. London. John Murray Publishers.

Owen, K. & Taljaard, J.J. (1989). Handbook for the use of Psychological and Scholastic Tests of IPER and the NIPER. Pretoria. Gutenberg Book Printers.

Ozsogomonyan, A. & Loftus, D. (1979). Predictors of General Chemistry Grades. Journal of Chemical Education. 56 (3). pp. 173 - 175.

Parsons, P.G. (1993). The student at risk. South African Journal of Higher Education. 7(1). pp. 24 - 32.

Porter, A. & Woods, T. (1987). Chemistry Tests for First Examinations. Stanley Thornes Publishers.

Pribyl, J.R. & Bodner, G.M. (1987). Spatial Ability and its Role in Organic Chemistry: A Study of four Organic Courses. Journal of Research in Science Teaching. 24 (3). pp. 229 - 240.

Russell, A.A. (1994). A Rationally Designed General Chemistry Diagnostic Test. Journal of Chemical Education. 71 (4). pp. 314 - 317.

Rutherford, M. & Watson, P. (1990). Selection of Students for Science Courses. South African Journal of Higher Education. 10(4). pp. 353 - 359.

Rutherford, M. (1992). The Selection Process for the Faculty of Science, University of the Witwatersrand and 'downstream' concomitant resultants - or Access and Success in Science. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium. (pp. 38 - 42).

Sax, G. (1989). Principles of Educational and Psychological Measurement and Evaluation. 3rd ed. Belmont. Wadsworth Publishing Company.

Scarr, S. (1977). Testing Minority Children: Why, How, And With What Effects? In Bossone, R.M., Weiner, M. (Eds.). National Conference on Testing: Major Issues: Proceedings. Nov. 17,18, 1977. Center For Advanced Study in Education. The Graduate School and University Center of the City University of New York.

Scott, J. (1992). In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 88 - 93).

Sharwood, D.W. (1998). The Evaluation of the Foundation Programme at the Port Elizabeth Technikon. Doctoral Thesis. University of the Witwatersrand. South Africa.

Shochet, I.M. (1994). The moderator effect of cognitive modifiability on a traditional undergraduate admissions test for disadvantaged African students in South Africa. South African Journal of Psychology. 24(4). pp. 208 – 215.

Skevington, J. (1988). Practical Assessment Physics for GCSE. London. Unwin Hyman.

Skuy, M., Zolezzi, S., Mentis, M., Fridjhon, P. & Cockcroft, K. (1996). Selection of advantaged and disadvantaged South African students for university admission. South African Journal of Higher Education. 10(1). pp. 110 – 118.

South Africa. Dept. of Education. (1997). Education White Paper 3: A Programme for the Transformation of Higher Education. Pretoria: Government Printer.

South Africa. National Dept. of Education. (1997). Curriculum 2005 Lifelong Learning for the 21st Century. [Brochure]

South African Survey (2000/01). Education. (pp. 253-304). South Africa. South African Race Relations.

South African Yearbook (2001/02). Education. (pp. 179-201). South Africa. Government Communication and Information System.

Stephenson, B. & Fisher, H.K. (1983). The Ontario Assessment Instrument Pool. Physics. Senior Division. Ontario. Ministry of Education.

Steyn, J.C. (1995). Quality education and / or equality in education: an ongoing debate. South African Journal of Education. 15(1). pp. 22 - 25.

Suransky, L. (1992). Some Perspectives from Historically African Institutions on the realties of Selection and Admissions. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 19 - 37).

Sweetland, R.C. & Keyser, D.J. (1983). Tests: A Comprehensive Reference for assessments in Psychology, Education and Business. Missouri. Test Corporation of America.

Taylor, J. (1992). The Role of Psychometric Tests as an Aid to Alternative Selection Methods into University. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 85 - 88).

Texas Academic Skills Program (TASP). (1998). Available from Internet URL http://www.tasp.nesinc.com

Thorndike, R.L. (1982). Applied Psychometrics. Boston. Houghton Mifflin.

Thorndike, R.L. & Hagen, E.P. (1969). Measurement and Evaluation in Psychology and Education. 3rd edition. New York. Houghton Mifflin.

Tyler, L.E. (1971). Tests and Measurement. 2nd ed. Englewoods Cliffs, N.J Prentice-Hall.

van der Merwe, P. (2000). A New Access Advice Model for the Admission and Channelling of Students at the University of Stellenbosch. In National Conference on Access with Success into Further and Higher Education. University of the Orange Free State. 25-26 May 2000.

van Eeden, R., de Beer, M. & Coetzee, C.H. (2001). Cognitive ability, learning potential, and personality traits as predictors of academic achievement by engineering and other science and technology students. South African Journal of Higher Education. 15(1). pp. 171-179.

van Rooyen, E. (2001). Die voorspelling van die akademiese prestasie van students in 'n universiteitsoorbruggingsprogram. South African Journal of Higher Education. 15(1). pp. 180-189.

Vera, N. (1992). Some Perspectives from Historically African Institutions on the realties of Selection and Admissions. In Badsha, N., Griesel, H., Smith, M., Yeld, N. (Eds.). Cintsa Admissions Symposium (pp. 19 - 37).

Volmink, J. (1987). Foundation Year in Science. In du Toit, B., Moëd,M. (Eds.). ASPECTS 8 Proceedings of the 1987 ASP Conference. pp. 129-130.

Waddington, D.J. (Ed.). (1984). Teaching School Chemistry. Paris. UNESCO (Publishers).

Walsh, W.B. & Betz, N.E. (1985). Tests and Assessment. New Jersey. Prentice-Hall.

Warren, D. (1998). Educational intervention in higher education: from 'academic support' to 'academic development'. South African Journal of Higher Education. 12(3). pp. 76 – 87.

Wood, D.A. (1961). Test Construction. Development and Interpretation of Achievement Tests. Columbus, Ohio. Merrill Books.

Woodbridge, N.B. (1995). Towards equity in education in terms of the Farrell Model: promoting the principles of the White Paper. South African Journal of Education. 15(4). pp. 192 - 195.

Yeld, N. & Haeck, W. (1997). Educational Histories and Academic Potential: can tests deliver? Assessment and Evaluation in Higher Education. 22 (1). pp. 5 - 16

Zaaiman, H. (1996). The quantification of educational disadvantage for selection. Necessary? Practical? Academic Development. 2 (2). pp. 113 - 123 .

Zaaiman, H., van der Flier, H. & Thijs, G.D. (1998). Selecting South African higher education students: critical issues and proposed solutions. South African Journal of Higher Education. 12(3). pp. 96 - 101.

ANNEXURE A PHYSICS QUESTIONNAIRE

1. **Below are all the Physics topics examined in Grade 12. Indicate the topics you believe should be included in a science entrance test for the courses Analytical Chemistry, Biomedical Technology and Environmental Health at South African Technikons.**

   Also, indicate the levels on which they should use their knowledge according to the scale below:

1	Recall memory only	2	understand simple exercises	3	application problem solving of "standard" – type	4	difficult/more complex question of "unfamiliar" situation

Mark with a cross (x) in the appropriate block (s).

	Topics	1	2	3	4

1.1 Definition of a vector		4	2	2	
1.2 Definition of a scalar		5	1	2	
1.3 Resultant of vectors			1	5	2
1.4 The concept of equilibrium		1	4	2	1
1.5 Equilibrant of vectors		2	3	1	1
1.6 Graphical representation of vectors		2	2	3	
1.7 Addition of vectors			2	4	2
1.8 Determine the components of a vector (graphically)		1	2	3	1
1.9 Determine the components of a vector (calculation)			1	4	2
1.10 The relationship among three co-planar forces in equilibrium			2	3	2
1.11 Speed and velocity			4	2	
1.12 Velocity and acceleration as vector quantities			4	2	1
1.13 Ticker-timer: concepts of speed, velocity and acceleration of a ticker-timer			2		1
1.14 Graphs of displacement/time for uniform motion				3	1
1.15 Graphs of displacement/time for accelerated motion			2	2	1
1.16 Graphs of velocity/time for uniform motion			1	3	1
1.17 Graphs of velocity/time for accelerated motion			2	2	2
1.18 Calculations using the equations of motion			1	4	3
1.19 Interpretation of experimental results of motion			3	1	2
		1	**2**	**3**	
2 Bodies in Motion 2.1 Newton's first law of motion		1	3	2	1
2.2 Applications of Newton's First Law of Motion			4	2	1
2.3 Newton's Second Law of Motion		1	3	3	1
2.4 What is the resultant force		1	2	3	2
2.5 Calculations using F(res) = ma			1	4	3
2.6 The identification of forces acting on a body in a given situation			1	4	2
2.7 Concept of a constant force produces a constant acceleration			1	3	2
2.8 The force exerted on a given mass is proportional to the acceleration it produces			2	3	1
2.9 Definition of a Newton		5	1	1	
2.10 Newton's Law of Universal Gravitation		1	4		

2.11 Application of Newton's Third Law			3	2	1
2.12 The universal aspect of gravitational attraction		3	2	2	
2.13 Calculations involving $F= \frac{G m_1 m_2}{r^2}$			3	2	1
2.14 Free-fall			3	4	1
2.15 Equations of motion for falling bodies			2	4	2
2.16 Weight = mass x gravitational acceleration		3	1	2	
2.17 Momentum as a vector quantity			3	2	1
2.18 Change in momentum		1	1	4	1
2.19 Impulse = F_t = m (_v)		1	1	4	1
2.20 Momentum and Newton's Second Law		3		1	2
2.21 Conservation of momentum in straight line conditions		2	1	3	1
2.22 Calculations involving the principle of the conservation of Linear Momentum		1	1	3	2
2.23 Definition of work done		3	1	1	1
2.24 Work done = energy transferred		1	1	3	1
2.25 Conservation of energy			3	3	1
2.26 Potential Energy of an object		1	2	3	1
2.27 Kinetic Energy of an object		1	2	3	1
2.28 Conservation of Mechanical Energy			3	2	1
2.29 Power = rate of work done		1	3	2	1
2.30 Calculations involving work done, energy, power			1	5	1
		1	**2**	**3**	**4**
3. Electrostatics 3.1 Electrostatics - definition of:		5	1		
3.2 The Principle of the Conservation of Charge		3	3		
3.3 Forces between charges		1	2	3	1
3.4 Coulomb's Law		4	1	3	
3.5 Calculation involving $F= \frac{kQ_1Q_2}{r^2}$			1	6	2
3.6 What is an electric field		4	2		
3.7 Electric field lines around charges		2	4		
3.8 Forces in an electric field		1	3	1	1
3.9 Concept of field strength (intensity)		1	3	3	
3.10 Work done in moving charges in an electric field		1	1	2	1
3.11 Potential energy of a charge in an uniform electrostatic field		1	1	2	

3.12 Potential difference between points in a field		1	2	1	
3.13 Electric field between parallel plates		2	1	1	1
3.14 Discussion of Millikan's experiment" QE = mg		1	1	1	1
3.15 Charge on an electron		4		1	1
3.16 Calculations limited to uniform fields and field strength around a point charge		1	1	1	2
4. The Electric Current 4.1 Definition of electric current		4	1	1	
4.2 Force experienced by an electric - bearing conductor in a magnetic field			2	2	1
4.3 Factors influencing the magnitude of the force on a current-bearing conductor in a magnetic field			2	2	1
4.4 Force between two parallel current - carrying conductors			2	3	
4.5 Calculations involving $F = \frac{KI_1 I_2 l}{d}$		1	1	3	
4.6 Calculations involving electric current			2	2	2
4.7 Definition of the ampere		5		1	
4.8 Resistance and Ohm's Law		2	1	3	1
4.9 Definition of the Ohm		6		1	
4.10 Concept of resistance		4	2	1	
4.11 Ohm's Law		2	1	3	1
4.12 Circuits - resistances in series			2	3	2
		1	**2**	**3**	**4**
4.13 Circuits - resistances in parallel			2	3	2
4.14 Circuits - problems about circuits			2	2	4
4.15 Internal Resistance of a cell		1	1	2	2
4.16 Calculations involving Internal Resistance		1		3	2
4.17 Calculations excluding Internal Resistance		1		3	1
4.18 Electric Energy		2	1	1	1
4.19 Phenomenon of heating effect		2	2	1	1
4.20 Energy transferred to the conductor: $W= I^2Rt$		1	1	3	1
4.21 Power of an electric motor/bulb		2	2	1	1
4.22 The unit watt		5	1		
4.23 Definition of volt in terms of Watts per ampere		5			
4.24 Emf: rate of supply of energy per unit current. E = P/I		3	1	1	

4.25 The relationship between emf, potential difference and internal resistance		2		2	1
4.26 Calculations involving internal resistance		1		2	1
4.27 Concept of alternating current		3		1	
4.28 The difference between Direct current and Alternating current		4	1		
4.29 Physical quantities and their units		4	2		

2. Below are all the Physics experiments a Grade 12 learner should have performed. Indicate those you believe should be tested for in an entrance test.

Please mark with a cross (x)

2.1 The relationship between acceleration and force (constant mass)	5
2.2 The relationship between acceleration and force (force constant)	5
2.3 Determine "g" by a free fall method	2
2.4 The patterns of electric field lines around	1
2.4.1 - a single point charge	2
2.4.2 - two point charges	1
2.4.3 - a sphere	1
2.4.4 - between two oppositely charged parallel plates	1
2.5 The relationship among three forces in equilibrium acting at the same point	4
2.6 Determine the resultant of two non-parallel forces acting at the same point	5
2.7 Determine the period of a ticker-timer	2
2.8 Determine at least three walking speeds in m/s	3
2.9 The uniform velocity of a moving trolley leading to the graphs of displacement/time and velocity/time	4
2.10 The acceleration of a trolley leading to the graphs of displacement/time and velocity/time	3

3. I believe that a student entering one of the science courses at a Technikon should have the following experimental skills.

Also, rate the skills according to the scale below:

1. Always important	2. Sometimes important	3. Seldom important	4. Never important

	Topics	1	2	3	4
3.1 Systematic methods of work					
3.2 Make deductions from data					
3.3 Draw conclusions from data					
3.4 analyze a graph (proportionality)					
3.5 analyze a ticker tape					
3.6 interpret a graph					
3.7 interpret a ticket tape					
3.8 interpret results from an experiment					
3.9 draw up reports					
3.10 evaluate the results of an experiment					
3.11 Use an ammeter					
3.12 Use a massmeter					
3.13 Use a voltmeter					
		1	2	3	4
3.14 Use a thermometer					
3.15 Dilute an acid					
3.16 Apply knowledge to identify a given sample					
3.17 Follow instructions for practical work					
3.18 Select appropriate apparatus					
3.19 Handle and manipulate physics/chemical apparatus and material safely					
3.20 Make accurate observations					
3.21 Make accurate measurements (being aware of possible source of error)					
3.22 Record accurately and clearly the results of experiment					
3.23 Make generalisations from results of experiments					

3.24 Assemble apparatus correctly					
3.25 Plan and organise simple experimental investigations to test hypotheses					
3.26 Present physics/ chemical ideas in a clear and logical form					
3.27 Use the redox half reaction table to balance equations					
3.28 Select tests, procedures and practical techniques to investigate the validity of interpretations, conclusions, generalisation and predictions					
3.29 Skill in handling materials					
3.30 Devise an appropriate scheme and apparatus for solving a practical problem					
3.31 Should be able to classify data					
3.32 Should be able to speculate					
3.33 Solve the problems by designing, conducting and interpreting the results of simple experiments					

4. I believe that a student entering one of the science courses at Technikon should have the following general skills.

Also, rate the skills according to the scale:

1. Always useful	2. Sometimes useful	3. Seldom useful	4. Never useful

Mark with a cross (x) in the appropriate blocks

	Topics	1	2	3	4
4.1 Use of correct units					
4.2 Conversion of units					
4.3 Use given formula					

4.4 Apply laws and formulae					
4.5 Explain phenomena in terms of theories and models					
4.6.Translate data into					
4.6.1 - diagrammatic form					
4.6.2 - symbolic form					
4.6.3 - numerical form					
4.6.4 - written form					
4.7 Use data in					
4.7.1 - diagrammatic form					
4.7.2 - symbolic form					
4.7.3 - numerical form					
4.7.4 - written form					
4.8 Extract and evaluate information from that which is given					
4.9 Present information in a precise and logical form					
4.10 Recognise mistakes, misconceptions, unreliable data and assumptions					
4.11 Draw conclusions and formulate generalisations					
4.12. Apply definitions					
4.12.1 - principles					
4.12.2- concepts					
		1	**2**	**3**	**4**
4.12.3- laws					
4.12.4- models					
4.12.5- theories					
4.13. Application of physics/chemical patterns to					
4.13.1- interpret					
4.13.2- draw conclusions					
4.13.3- make generalisations					
4.13.4- make predictions					
4.14. Select appropriate facts to illustrate					
4.14.1- principles					
4.14.2- concepts					
4.14.3- theory					
4.14.4- models					
4.15 Select tests, procedures and practical techniques to					

investigate the validity of interpretations, conclusions, generalisations and predictions					
4.16 Should be able to interpret data with evidence of judgement and assessment					
4.17 Apply knowledge to new situations					
4.18 Knowledge to solve problems					
4.19 Apply proportional reasoning					
4.20 Be able to think logically					

5. Rate the importance of the following in an entrance test on a scale from 1 to 10; 1 being the least important and 10 being the most important.

	Scale									
	1	2	3	4	5	6	7	8	9	10
Knowledge (content)						2	1	2		3
Practical work							3	3	1	1
Skills	1	1	1		1	2	2			

ANNEXURE B CHEMISTRY QUESTIONNAIRE

1. Below are all the Chemistry topics examined in Grade 12. Indicate the topics you believe should be included in a science entrance test for the courses Analytical Chemistry, Biomedical Technology and Environmental Health at South African Technikons.

Also, indicate the levels on which they should use their knowledge according to the scale below:

1.	Recall/ Memory only	2.	Understand simple Exercises	3.	Application problem-solving of standard" type	4.	Difficult/more complex question "unfamiliar situation"

Mark with a cross (x) in the appropriate block(s)

	Topics	1	2	3	4

1. The kinetic model of matter and intermolecular Forces 1.1 Van Der Waals forces					
1.2 Hydrogen bonding					
1.3 Liquids – intermolecular forces in the liquid Phase					
1.4 Liquids – vapour liquid equilibrium					
1.5 Solids – intermolecular forces in molecular solids					
1.6 - intermolecular forces in network solids					
1.7 - intermolecular forces in ionic solids					
1.8 - intermolecular forces in metals					
1.9 Solutions – the nature of a solution					
Solutions – the solubility of a molecular solid in a non-polar solvent					
Solutions-the solubility of an ionic solid in polar solvent					
1.12 Solutions- concentration of solutions					
1.13 Solutions- standard solutions					
Gases- the relationship between the mean kinetic energy of gas molecules and temperature					

1.15 Gases – the meaning of STP (standard temperature and pressure)					
1.16 Gases – Boyle's Law					
1.17 Gases – the graphical illustration of deviations from ideal gas behaviour					
1.18 Gases – non-ideal gas behaviour					
1.19 Gases – calculations involving $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$					
Inorganic Chemistry 2.1 Inorganic Chemistry: concept of oxidation					
2.2 Concept - reduction					
2.3 Concept - oxidising agent					
2.4 Concept - reducing agent					

2.5 Concept - solubilities of salts					
2.6 Balancing of equations for redox reactions using redox half reaction tables					
2.7 Hydrogen Sulphide - preparation					
2.8 H_2S - reducing action with iron (III) – ions					
2.9 H_2S - precipitation reactions with metal salts					
2.10 Test for H_2S					
2.11 Sulphur dioxide – preparation					
2.12 SO_2 - solubility					
2.13 SO_2 - reducing action					
2.14 SO_2 - oxidising action					
2.15 Sulphur trioxide – catalytic oxidation of SO_2 (contact process)					
2.16 Sulphuric acid - dehydrating action					
2.17 H_2SO_4 - oxidising action					
2.18 H_2SO_4 – reaction with chlorides and nitrates					
2.19 H_2SO_4 - uses and applications					
2.20 Sulphates - test for					
2.21 Nitrogen - industrial preparation					
2.22 N_2 - uses of nitrogen					
2.23 Ammonia – laboratory preparation					
2.24 Ammonia – Haber process: preparation					
2.25 NH_3 - uses of					
2.26 NH_3 - solubility					
2.27 Ammonia salts -reaction when NH_4C1 is heated					
2.28 Nitrogen dioxide - laboratory preparation					
2.29 NO2 - influence of pressure and temperature on the molecular composition of NO2					
2.30 NO_2 - reversibility of the change					
2.31 Nitric acid - industrial preparation					
2.32 HNO_3 - catalytic oxidation of ammonia					
2.33 HNO_3 - decomposition on heating					
Oxidising action of HNO3 (conc) and HNO3					

(dil.)					
2.35 Uses of HNO3					
2.36 Nitrates - solubility					
2.37 Nitrates - reaction on heating					
2.38 Chlorine - laboratory preparation					
2.39 $C1_2$ - industrial preparation					
2.40 $C1_2$ - reaction with metals					
2.41 $C1_2$ - reaction with water					
2.42 $C1_2$ - uses of					
2.43 Hydrochloric acid- laboratory preparation					
2.44 HC1 - solubility					
2.45 HC1 - reaction with oxidising agents					
2.46 HC1 - uses					
2.47 Halides - solubility					
2.48 Halides - preparation reactions with silver nitrate					
3. Reaction rates and Chemical Equilibrium 3.1 Rates of reaction - definition of rate of a chemical reaction					
3.2 Measuring the rate of a reaction					
3.3 Factors influencing the rate of a reaction					
3.4 Collision Theory – energy of chemical reactions					
3.5 Graphical representation of Energy vs Time of chemical reactions					
3.6 Positive Reactions and Chemical Equilibrium: Definition of chemical equilibrium					
3.7 Dynamic nature of chemical equilibrium					
3.8 The equilibrium constant					
3.9 The equilibrium state and conditions					
3.10 Factors influencing equilibrium					
3.11 Le Chatelier: principle – application					
3.12 Equilibrium in solutions					
3.13 Dynamic nature of solubility equilibrium					
3.14 Dissociation equilibrium					

4. Acids and Bases 4.1 Definition of weak acid / base					
4.2 Definition of strong acid / base					
4.3 Definition of concentrated acid / base					
4.4 Equilibrium with H + (aq) ions					
4.5 Dissociation of acids and water					
4.6 The value and meaning of Kw					
4.7 pH – scale					
4.8 pH- concept in terms of H + (aq)					
4.9 Calculation of pH					
4.10 Proton transfer and its reversibility					
4.11 Hydrolysis of salts					
4.12 Acid – base filtrations					
4.13 Neutralization reaction					
4.14 The basic principles of volumetric analysis					
4.15 Calculations of concentration (in mol/dm^3)					
4.16 Standardization of Acids and Bases					
4.17. Calculations based on the filtration of an acid and a base					
5. Oxidation and Reduction - the electrochemical Cell Cu-Zn cell and its chemistry					
5.1 Comprehension and use of half-cell potential					
5.2 Prediction of redox reactions					
5.3 Calculations of emf of a cell					
6. Organic Chemistry 6.1 Organic Chemistry – definition					
6.2 The importance of Carbon-chemistry					
The structure of some organic compounds – spatial arrangement					
Nomenclature and classification of alkanes, haloalkanes, alkenes, alkyne, alcohols, carboxylic acids, esters, according to functional groups					
6.5 Hydrocarbons - reactions; addition, substitution, hydrogenation					
6.6 Formation of esters: carboxylic acid + alcohol					
6.7 Naming of esters					

2. Below are all the Chemistry experiments a Grade 12 learner should have performed. Indicate those you believe should be tested for in an entrance test.

Please mark with a cross (x)

The relationship between pressure and the volume of a given mass of gas (constant temperature)	
2.2 Test for hydrogen sulphide	
2.3 The reaction of sulphur dioxide with water	
2.4 The oxidising action of sulphur dioxide	
2.5 The precipitation reactions of soluble sulphates with aqueous solutions of calcium and barium salts	
2.6 Test for sulphates	
2.7 The heating of ammonium chloride	
2.8 The oxidising action of dilute and concentrated nitric acid with copper	
2.9 The reaction of soluble chlorides, bromides and iodides with silver nitrate Solution	
2.10 The factors which affect the rate of reactions	
2.11 The effect of temperature on the equilibrium in a chemical reaction	
2.12 The common ion effect on equilibrium in solutions	
2.13 Prepare a standard solution	
2.14 Standardisation of a dilute solution of a base/acid using a standard solution of an acid/base	
2.15 The metal displacement reaction of zinc with copper sulphate	

3. I believe that a student entering one of the science courses at a Technikon should have the following experimental skills.

Also, rate the skills according to the scale below:

1. Always important	2. Sometimes important	3. Seldom important	4. Never important

	Topics	1	2	3	4
3.1 Systematic methods of work					
3.2 Make deductions from data					
3.3 Draw conclusions from data					
3.4 analyze a graph (proportionality)					

3.5 analyze a ticker tape					
3.6 interpret a graph					
3.7 interpret a ticket tape					
3.8 interpret results from an experiment					
3.9 draw up reports					
3.10 evaluate the results of an experiment					
3.11 Use an ammeter					
3.12 Use a massmeter					
3.13 Use a voltmeter					
3.14 Use a thermometer					
3.15 Dilute an acid					
3.16 Apply knowledge to identify a given sample					
3.17 Follow instructions for practical work					
3.18 Select appropriate apparatus					
3.19 Handle and manipulate physics/chemical apparatus and material safely					
3.20 Make accurate observations					
3.21 Make accurate measurements (being aware of possible source of error)					
3.22 Record accurately and clearly the results of experiment					
3.23 Make generalisations from results of experiments					
3.24 Assemble apparatus correctly					
3.25 Plan and organise simple experimental investigations to test hypotheses					
3.26 Present physics/chemical ideas in a clear and logical form					
3.28 Select tests, procedures and practical techniques to investigate the validity of interpretations, conclusions, generalisation and predictions					
3.29 Skill in handling materials					
3.30 Devise an appropriate scheme and apparatus for solving a practical problem					
3.31 Should be able to classify data					
3.32 Should be able to speculate					
3.33 Solve the problems by designing, conducting and interpreting the results of simple experiments					

4. I believe that a student entering one of the science courses at Technikon should have the following general skills.

Also, rate the skills according to the scale:

1. Always useful	2. Sometimes useful	3. Seldom useful	4. Never useful

Mark with a cross (x) in the appropriate blocks

	Topics	1	2	3	4
4.1 Use of correct units					
4.2 Conversion of units					
4.3 Use given formula					
4.4 Apply laws and formulae					
4.5 Explain phenomena in terms of theories and models					
4.6.Translate data into					
4.6.1 - diagrammatic form					
4.6.2 - symbolic form					
4.6.3 - numerical form					
4.6.4 - written form					
4.7 Use data in					
4.7.1 - diagrammatic form					
4.7.2 - symbolic form					
4.7.3 - numerical form					
4.7.4 - written form					
4.8 Extract and evaluate information from that which is given					
4.9 Present information in a precise and logical form					
4.10 Recognise mistakes, misconceptions, unreliable data and assumptions					
4.11 Draw conclusions and formulate generalisations					
4.12. Apply definitions					
4.12.1 - principles					
4.12.2- concepts					
4.12.3- laws					

4.12.4- models					
4.12.5- theories					
4.13. Application of physics/chemical patterns to					
4.13.1- interpret					
4.13.2- draw conclusions					
4.13.3- make generalisations					
4.13.4- make predictions					
4.14. Select appropriate facts to illustrate					
4.14.1- principles					
4.14.2- concepts					
4.14.3- theory					
4.14.4- models					
4.15 Select tests, procedures and practical techniques to investigate the validity of interpretations, conclusions, generalisations and predictions					
4.16 Should be able to interpret data with evidence of judgement and assessment					
4.17 Apply knowledge to new situations					
4.18 Knowledge to solve problems					
4.19 Apply proportional reasoning					
4.20 Be able to think logically					

5. Rate the importance of the following in an entrance test on a scale from 1 to 10; 1 being the least important and 10 being the most important.

Knowledge (content)	
Practical work	
Skills	

ANNEXURE C RESPONSES – PHYSICS QUESTIONNAIRE

1. Below are all the Physics topics examined in Grade 12. Indicate the topics you believe should be included in a science entrance test for the courses Analytical Chemistry, Biomedical Technology and Environmental Health at South African Technikons.

Also, indicate the levels on which they should use their knowledge according to the scale below:

1.	Recall memory only	2.	understand simple exercises	3.	application problem solving of "standard" - type	4.	difficult/more complex question of "unfamiliar" situation

Mark with a cross (x) in the appropriate block (s).

VECTORS	Topics	1	2	3	4
1.1 Definition of a vector		4	2	2	
1.2 Definition of a scalar		5			

1.3 Resultant of vectors					
1.4 The concept of equilibrium		1			
1.5 Equilibrant of vectors					
1.6 Graphical representation of vectors					
1.7 Addition of vectors					
1.8 Determine the components of a vector (graphically)					
1.9 Determine the components of a vector (calculation)					
1.10 The relationship among three co-planar forces in equilibrium					
1.11 Speed and velocity					
1.12 Velocity and acceleration as vector quantities					
1.13 Ticker-timer: concepts of speed, velocity and acceleration of a ticker-timer					
1.14 Graphs of displacement/time for uniform motion					
1.15 Graphs of displacement/time for accelerated motion					
1.16 Graphs of velocity/time for uniform motion					
1.17 Graphs of velocity/time for accelerated motion					
1.18 Calculations using the equations of motion					
1.19 Interpretation of experimental results of motion					
2. Bodies in Motion 2.1 Newton's First Law of Motion					
2.2 Applications of Newton's First Law of Motion					
2.3 Newton's Second Law of Motion					
2.4 What is the resultant force					
2.5 Calculations using F(res) = ma					
2.6 The identification of forces acting on a body in a given situation					
2.7 Concept of a constant force produces a constant acceleration					
2.8 The force exerted on a given mass is proportional to the acceleration it produces					
2.9 Definition of a newton					
2.10 Newton's Law of Universal Gravitation					
2.11 Application of Newton's Third Law					
2.12 The universal aspect of gravitational attraction					
2.13 Calculations involving $F= \frac{G\, m_1\, m_2}{r^2}$					
2.14 Free-fall					

2.15 Equations of motion for falling bodies					
2.16 Weight = mass x gravitational acceleration					
2.17 Momentum as a vector quantity					
2.18 Change in momentum					
2.19 Impulse = F_t = m (_v)					
2.20 Momentum and Newton's Second Law					
2.21 Conservation of momentum in straight line conditions					
2.22 Calculations involving the principle of the conservation of Linear Momentum					
2.23 Definition of work done					
2.24 Work done = energy transferred					
2.25 Conservation of energy					
2.26 Potential Energy of an object					
2.27 Kinetic Energy of an object					
2.28 Conservation of Mechanical Energy					
2.29 Power = rate of work done					
2.30 Calculations involving work done, energy, power					
3. Electrostatics 3.1 Electrostatics - definition of:					
3.2 The Principle of the Conservation of Charge					
3.3 Forces between charges					
3.4 Coulomb's Law					
3.5 Calculation involving $F= \frac{kQ_1Q_2}{r^2}$					
3.6 What is an electric field					
3.7 Electric field lines around charges					
3.8 Forces in an electric field					
3.9 Concept of field strength (intensity)					
3.10 Work done in moving charges in an electric field					
3.11 Potential energy of a charge in an uniform electrostatic field					
3.12 Potential difference between points in a field					
3.13 Electric field between parallel plates					
3.14 Discussion of Millikan's experiment" QE = mg					
3.15 Charge on an electron					
3.16 Calculations limited to uniform fields and field strength around a point charge					

4. The Electric Current 4.1 Definition of electric current					
4.2 Force experienced by an electric - bearing conductor in a magnetic field					
4.3 Factors influencing the magnitude of the force on a current-bearing conductor in a magnetic field					
4.4 Force between two parallel current - carrying conductors					
4.5 Calculations involving $F = \frac{KI_1 I_2 l}{d}$					
4.6 Calculations involving electric current					
4.7 Definition of the ampere					
4.8 Resistance and Ohm's Law					
4.9 Definition of the Ohm					
4.10 Concept of resistance					
4.11 Ohm's Law					
4.12 Circuits - resistances in series					
4.13 Circuits - resistances in parallel					
4.14 Circuits - problems about circuits					
4.15 Internal Resistanceof acell					
4.16 Calculations involving Internal Resistance					
4.17 Calculations excluding Internal Resistance					
4.18 Electric Energy					
4.19 Phenomenon of heating effect					
4.20 Energy transferred to the conductor: $W= I^2Rt$					
4.21 Power of an electric motor/bulb					
4.22 The unit watt					
4.23 Definition of volt in terms of Watts per ampere					
4.24 Emf: rate of supply of energy per unit current. $E = P/I$					
4.25 The relationship between emf, potential difference and internal resistance					
4.26 Calculations involving internal resistance					
4.27 Concept of alternating current					
4.28 The difference between Direct current and Alternating current					
4.29 Physical quantities and their units					

3. Below are all the Physics experiments a Grade 12 learner should have performed. Indicate those you believe should be tested for in an entrance test.

Please mark with a cross (x)

2.1 The relationship between acceleration and force (constant mass)	
2.2 The relationship between acceleration and force (force constant)	
2.3 Determine "g" by a free fall method	
2.4 The patterns of electric field lines around	
2.4.1 - a single point charge	
2.4.2 - two point charges	
2.4.3 - a sphere	
2.4.4 - between two oppositely charged parallel plates	
2.5 The relationship among three forces in equilibrium acting at the same point	
2.6 Determine the resultant of two non-parallel forces acting at the same point	
2.7 Determine the period of a ticker-timer	
2.8 Determine at least three walking speeds in m/s	
2.9 The uniform velocity of a moving trolley leading to the graphs of displacement/time and velocity/time	
2.10 The acceleration of a trolley leading to the graphs of displacement/time and velocity/time	

3. I believe that a student entering one of the science courses at a Technikon should have the following experimental skills

Also, Rate the skills according to the scale below:

1. Always important	2. Sometimes important	3. Seldom important	4. Never important

	Topics	1	2	3	4
3.1 Systematic methods of work					
3.2 Make deductions from data					
3.3 Draw conclusions from data					

3.4 analyze a graph (proportionality)					
3.5 analyze a ticker tape					
3.6 interpret a graph					
3.7 interpret a ticket tape					
3.8 interpret results from an experiment					
3.9 draw up reports					
3.10 evaluate the results of an experiment					
3.11 Use an ammeter					
3.12 Use a massmeter					
3.13 Use a voltmeter					
3.14 Use a thermometer					
3.15 Dilute an acid					
3.16 Apply knowledge to identify a given sample					
3.17 Follow instructions for practical work					
3.18 Select appropriate apparatus					
3.19 Handle and manipulate physics/chemical apparatus and material safely					
3.20 Make accurate observations					
3.21 Make accurate measurements (being aware of possible source of error)					
3.22 Record accurately and clearly the results of experiment					
3.23 Make generalisations from results of experiments					
3.24 Assemble apparatus correctly					
3.25 Plan and organise simple experimental investigations to test hypotheses					
3.26 Present physics/ chemical ideas in a clear and logical form					
3.27 Use the redox half reaction table to balance equations					
3.28 Select tests, procedures and practical techniques to investigate the validity of interpretations, conclusions, generalisation and predictions					
3.29 Skill in handling materials					
3.30 Devise an appropriate scheme and apparatus for solving a practical problem					
3.31 Should be able to classify data					
3.32 Should be able to speculate					
3.33 Solve the problems by designing, conducting and interpreting the results of simple experiments					

4. I believe that a student entering one of the science courses at Technikon should have the following general skills.

Also, rate the skills according to the scale:

1. Always useful	2. Sometimes useful	3. Seldom useful	4. Never useful

Mark with a cross (x) in the appropriate blocks

	Topics	1	2	3	4
4.1 Use of correct units					
4.2 Conversion of units					
4.3 Use given formula					
4.4 Apply laws and formulae					
4.5 Explain phenomena in terms of theories and models					
4.6.Translate data into					
4.6.1 - diagrammatic form					
4.6.2 - symbolic form					
4.6.3 - numerical form					
4.6.4 - written form					
4.7 Use data in					
4.7.1 - diagrammatic form					
4.7.2 - symbolic form					
4.7.3 - numerical form					
4.7.4 - written form					
4.8 Extract and evaluate information from that which is given					
4.9 Present information in a precise and logical form					
4.10 Recognise mistakes, misconceptions, unreliable data and assumptions					
4.11 Draw conclusions and formulate generalisations					
4.12. Apply definitions					
4.12.1 - principles					
4.12.2 - concepts					
4.12.3 - laws					
4.12.4 - models					

4.12.5- theories					
4.13. Application of physics/chemical patterns to					
4.13.1- interpret					
4.13.2- draw conclusions					
4.13.3- make generalisations					
4.13.4- make predictions					
4.14. Select appropriate facts to illustrate					
4.14.1- principles					
4.14.2- concepts					
4.14.3- theory					
4.14.4- models					
4.15 Select tests, procedures and practical techniques to investigate the validity of interpretations, conclusions, generalisations and predictions					
4.16 Should be able to interpret data with evidence of judgement and assessment					
4.17 Apply knowledge to new situations					
4.18 Knowledge to solve problems					
4.19 Apply proportional reasoning					
4.20 Be able to think logically					

5. Rate the importance of the following in an entrance test on a scale from 1 to 10; 1 being the least important and 10 being the most important

Knowledge (content)	
Practical work	
Skills	

ANNEXURE D RESPONSES – CHEMISTRY QUESTIONNAIRE

1. Below are all the Chemistry topics examined in Grade 12. Indicate the topics you believe should be included in a science entrance test for the courses Analytical Chemistry, Biomedical Technology and Environmental Health at South African Technikons.

Also, indicate the levels on which they should use their knowledge according to the scale below:

1.	Recall/ Memory only	2.	Understand simple Exercises	3.	Application problem-solving of standard" type	4.	Difficult/more complex question "unfamiliar situation"

Mark with a cross (x) in the appropriate block(s)

	Topics	1	2	3	4
2. The kinetic model of matter and intermolecular Forces 1.1 Van Der Waals forces		3	2	1	
1.2 Hydrogen bonding		3	4	2	
2.3 Liquids – intermolecular forces in the liquid Phase		4	5		
1.4 Liquids – vapour liquid equilibrium		1	4	1	
1.5 Solids – intermolecular forces in molecular solids		3	4	2	
1.6 - intermolecular forces in network solids		3	4	1	

1.7 - intermolecular forces in ionic solids		3	4	2	
1.8 - intermolecular forces in metals		3	4	1	
1.9 Solutions – the nature of a solution		3	2	5	
1.10 Solutions – the solubility of a molecular solid in a non-polar solvent		4	2	4	
1.11 Solutions-the solubility of an ionic solid in polar solvent		4	2	3	
1.12 Solutions- concentration of solutions		1	1	5	3
1.13 Solutions- standard solutions			2	6	2
1.14 Gases- the relationship between the mean kinetic energy of gas molecules and temperature		1	3	3	
1.15 Gases – the meaning of STP (standard temperature and pressure)		2	3	4	
1.16 Gases – Boyle's Law		2	4	3	
1.17 Gases – the graphical illustration of deviations from ideal gas behaviour			5	1	
1.18 Gases – non-ideal gas behaviour		2	3	1	
1.19 Gases – calculations involving $\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$			4	4	1
Inorganic Chemistry 2.1 Inorganic Chemistry: concept of oxidation		3	5	1	1
2.2 Concept - reduction		3	6	1	1
2.3 Concept - oxidising agent		3	6	1	1
2.4 Concept - reducing agent		3	6	1	1
2.5 Concept - solubilities of salts		2	5	2	
2.6 Balancing of equations for redox reactions using redox half reaction tables			5	4	1
2.7 Hydrogen Sulphide - preparation		2	3	2	
2.8 H_2S - reducing action with iron (III) – ions		2	3	2	
2.9 H_2S - precipitation reactions with metal salts		2	3	2	
2.10 Test for H_2S		2	4	1	
2.11 Sulphur dioxide – preparation		2	4	1	
2.12 SO_2 - solubility		2	4	1	
2.13 SO_2 - reducing action		2	4	1	
2.14 SO_2 - oxidising action		2	4	1	
2.15 Sulphur trioxide – catalytic oxidation of SO_2 (contact process)		2	3	2	
2.16 Sulphuric acid - dehydrating action		2	4	2	
2.17 H_2SO_4 - oxidising action		2	5	1	
2.18 H_2SO_4 – reaction with chlorides and nitrates		2	5	1	
2.19 H_2SO_4 - uses and applications		3	4		1

2.20 Sulphates - test for		3	4		
2.21 Nitrogen - industrial preparation		4	2		1
2.22 N_2 - uses of nitrogen		3	2	1	
2.23 Ammonia – laboratory preparation		3	3	1	
2.24 Ammonia – Haber process: preparation		4	2	2	
2.25 NH_3 - uses of		4	4		
2.26 NH_3 - solubility		3	3	1	
2.27 Ammonia salts -reaction when NH_4C1 is heated		4	3		
2.28 Nitrogen dioxide - laboratory preparation		3	3		
2.29 NO2 - influence of pressure and temperature on the molecular composition of NO2			6	1	
2.30 NO2 - reversibility of the change			4	2	
2.31 Nitric acid - industrial preparation		4	3		1
2.32 HNO_3 - catalytic oxidation of ammonia		4	1		1
2.33 HNO_3 - decomposition on heating		4	1		1
2.34 Oxidising action of HNO3 (conc) and HNO3 (dil.)		4	3		1
2.35 Uses of HNO3		4	3	1	
2.36 Nitrates - solubility		4	2	1	
2.37 Nitrates - reaction on heating		1	5	1	
2.38 Chlorine - laboratory preparation		4	3	1	
2.39 $C1_2$ - industrial preparation		3	3		1
2.40 $C1_2$ - reaction with metals		3	3	1	
2.41 $C1_2$ - reaction with water		3	3	1	
2.42 $C1_2$ - uses of		4	3	1	
2.43 Hydrochloric acid- laboratory preparation		4	3	1	
2.44 HC1 - solubility		3	4	1	
2.45 HC1 - reaction with oxidising agents		3	3		1
2.46 HC1 - uses		4	3	1	
2.47 Halides - solubility		5	2	1	
2.48 Halides - preparation reactions with silver nitrate		2	5	1	
3. Reaction rates and Chemical Equilibrium 3.1 Rates of reaction - definition of rate of a chemical reaction		2	6	3	
3.2 Measuring the rate of a reaction			4	4	
3.3 Factors influencing the rate of a reaction		3	3	3	1

3.4 Collision Theory – energy of chemical reactions		3	3	2	
3.5 Graphical representation of Energy vs Time of chemical reactions			4	3	
Positive Reactions and Chemical Equilibrium: Definition of chemical equilibrium		5	4	2	
3.7 Dynamic nature of chemical equilibrium		3	5	3	
3.8 The equilibrium constant		3	4	1	2
3.9 The equilibrium state and conditions		3	4	2	1
3.10 Factors influencing equilibrium		1	5	3	2
3.11 Le Chatelier: principle – application		2	4	4	1
3.12 Equilibrium in solutions		1	5	3	
3.13 Dynamic nature of solubility equilibrium		1	5	1	2
3.14 Dissociation equilibrium		1	6	1	1
4. Acids and Bases 4.1 Definition of weak acid / base		5	3	4	
4.2 Definition of strong acid / base		5	3	4	
4.3 Definition of concentrated acid / base		5	3	4	
4.4 Equilibrium with H + (aq) ions		2	2	5	
4.5 Dissociation of acids and water		2	2	6	
4.6 The value and meaning of Kw		3	1	5	1
4.7 pH – scale		4	1	5	
4.8 pH- concept in terms of H + (aq)		2	1	5	1
4.9 Calculation of Ph			3	4	2
4.10 Proton transfer and its reversibility			4	4	1
4.11 Hydrolysis of salts		1	4	2	1
4.12 Acid – base filtrations		3	2	2	1
4.13 Neutralization reaction		3	3	5	
4.14 The basic principles of volumetric analysis			6	4	
4.15 Calculations of concentration (in mol/dm^3)			3	3	4
4.16 Standardization of Acids and Bases			3	6	1
4.17 Calculations based on the filtration of an acid and a base			4	2	2
6. Oxidation and Reduction - the electrochemical Cell Cu-Zn cell and its chemistry			8		2
5.1 Comprehension and use of half-cell potential		1	6	1	1
5.2 Prediction of redox reactions			5	2	2
5.3 Calculations of emf of a cell		1	2	3	2
6. Organic Chemistry 6.1 Organic Chemistry – definition		8	2		1

6.2 The importance of Carbon-chemistry		5	3	1	2
6.3 The structure of some organic compounds – spatial arrangement		4	2	3	1
6.4 Nomenclature and classification of alkanes, haloalkanes, alkenes, alkyne, alcohols, carboxylic acids, esters, according to functional groups		2	4	4	1
6.5 Hydrocarbons - reactions; addition, substitution, hydrogenation		2	1	4	1
6.6 Formation of esters: carboxylic acid + alcohol		2	2	3	1
6.7 Naming of esters		2	2	3	1

2. Below are all the Chemistry experiments a Grade 12 learner should have performed. Indicate those you believe should be tested for in an entrance test.

Please mark with a cross (x)

The relationship between pressure and the volume of a given mass of gas (constant temperature)	7
2.2 Test for hydrogen sulphide	2
2.3 The reaction of sulphur dioxide with water	3
2.4 The oxidising action of sulphur dioxide	2
2.5 The precipitation reactions of soluble sulphates with aqueous solutions of calcium and barium salts	5
2.6 Test for sulphates	6
2.7 The heating of ammonium chloride	2
2.8 The oxidising action of dilute and concentrated nitric acid with copper	4
2.14 The reaction of soluble chlorides, bromides and iodides with silver nitrate Solution	6
2.10 The factors which affect the rate of reactions	6
2.11 The effect of temperature on the equilibrium in a chemical reaction	6
2.12 The common ion effect on equilibrium in solutions	5
2.13 Prepare a standard solution	9
2.16 Standardisation of a dilute solution of a base/acid using a standard solution of an acid/base	8
2.15 The metal displacement reaction of zinc with copper sulphate	5

3. I believe that a student entering one of the science courses at a Technikon should have the following experimental skills.

Also, Rate the skills according to the scale below:

1. Always important	2. Sometimes important	3. Seldom important	4. Never important

NB: The votes from the Physics Questionnaire are given in brackets.

	Topics	1	2	3	4
3.1 Systematic methods of work		11(6)			
3.2 Make deductions from data		8(3)	3(4)		
3.3 Draw conclusions from data		7(3)	4(4)		
3.4 analyze a graph (proportionality)		8(3)	4(3)		
3.5 analyze a ticker tape		(2)	3(1)	1(1)	(1)
3.6 interpret a graph		8(4)	3(2)		
3.7 interpret a ticket tape		(3)	3(1)	1	(1)
3.8 interpret results from an experiment		9(4)	2(2)		
3.9 draw up reports		8(4)	3(2)		
3.10 evaluate the results of an experiment		8(4)	3(1)	(1)	
3.11 Use an ammeter		3(3)	4(4)	1	
3.12 Use a massmeter		5(3)	3(4)	1	
3.13 Use a voltmeter		3(3)	4(4)	1	
3.14 Use a thermometer		4(3)	5(5)		
3.15 Dilute an acid		7(2)	3(5)	1	
3.16 Apply knowledge to identify a given sample		4(2)	4(2)	(1)	
3.17 Follow instructions for practical work		10(6)	1(2)		
3.18 Select appropriate apparatus		8(4)	2(1)		
3.19 Handle and manipulate physics/chemical apparatus and material safely		10(6)	1		
3.20 Make accurate observations		11(5)	(2)		
3.21 Make accurate measurements (being aware of possible source of error)		10(3)	2(3)		
3.22 Record accurately and clearly the results of experiment		12(6)	(1)		
3.23 Make generalisations from results of experiments		3(1)	6(4)	(1)	
3.24 Assemble apparatus correctly		9(2)	1(3)	(1)	
3.25 Plan and organise simple experimental investigations to test hypotheses		6(1)	4(2)	1(2)	
3.26 Present physics/ chemical ideas in a clear and logical form		8(1)	3(5)		
3.27 Use the redox half reaction table to balance equations		2(1)	4(2)	3(1)	
3.28 Select tests, procedures and practical techniques to					

investigate the validity of interpretations, conclusions, generalisation and predictions		4(1)	1(1)	2(3)	
3.29 Skill in handling materials		6(3)	4(3)		
3.30 Devise an appropriate scheme and apparatus for solving a practical problem		3(1)	4(3)	(1)	
3.31 Should be able to classify data		3(2)	5(3)	(1)	
3.32 Should be able to speculate		4(1)	6(1)	(5)	
3.33 Solve the problems by designing, conducting and interpreting the results of simple experiments		3(2)	5(2)	(1)	

4. I believe that a student entering one of the science courses at Technikon should have the following general skills.

Also, rate the skills according to the scale:

1. Always useful	2. Sometimes useful	3. Seldom useful	4. Never useful

* The votes for the Physics questionnaire are given in brackets.

Mark with a cross (x) in the appropriate blocks

	Topics	1	2	3	4
4.1 Use of correct units		12(7)	(1)		
4.2 Conversion of units		10(6)	2(2)		
4.3 Use given formula		7(6)	2(2)		
4.4 Apply laws and formulae		5(6)	3(2)		
4.5 Explain phenomena in terms of theories and models		(2)	7(3)	1(2)	
4.6.Translate data into					
4.6.1 - diagrammatic form		4(2)	4(4)		
4.6.2 - symbolic form		5(3)	3(4)		
4.6.3 - numerical form		7(3)	2(4)		
4.6.4 - written form		6(2)	2(4)		
4.7 Use data in					
4.7.1 - diagrammatic form		6(1)	3(6)		
4.7.2 - symbolic form		4(2)	3(4)	(2)	
4.7.3 - numerical form		8(3)	2(4)		
4.7.4 - written form		8(3)	1(4)		
4.8 Extract and evaluate information from that which is given		10(7)	1(1)		

4.9 Present information in a precise and logical form		10(6)	2(2)		
4.10 Recognise mistakes, misconceptions, unreliable data and assumptions		7(3)	3(3)		
4.11 Draw conclusions and formulate generalisations		8(1)	3(6)		
4.12. Apply definitions		3(3)	(1)		
4.12.1 - principles		8(5)	2(2)		
4.12.2- concepts		8(5)	2(1)	(1)	
4.12.3- laws		4(5)	4(1)		
4.12.4- models		3(3)	5(3)	(1)	
4.12.5- theories		3(3)	4(2)	1(1)	
4.13. Application of physics/chemical patterns to					
4.13.1- interpret		8(2)	(4)		
4.13.2- draw conclusions		7(2)	1(4)		
4.13.3- make generalisations		4(2)	4(3)	(1)	
4.13.4- make predictions		5(1)	3(4)	(1)	
4.14. Select appropriate facts to illustrate					
4.14.1- principles		5(2)	4(5)	(1)	
4.14.2- concepts		5(2)	4(5)	(1)	
4.14.3- theory		3(1)	6(3)	(2)	
4.14.4- models		2(1)	7(3)	(2)	
4.15 Select tests, procedures and practical techniques to investigate the validity of interpretations, conclusions, generalisations and predictions		2(1)	5(1)	(3)	
4.16 Should be able to interpret data with evidence of judgement and assessment		3(3)	4(1)	(2)	
4.17 Apply knowledge to new situations		9(1)	1(4)	(2)	
4.18 Knowledge to solve problems		10(6)	(2)		
4.19 Apply proportional reasoning		9(3)	2(3)	(1)	
4.20 Be able to think logically		10(5)	1(2)		

5.Rate the importance of the following in an entrance test on a scale from 1 to 10; 1 being the least important and 10 being the most important

Scale	1	2	3	4	5	6	7	8	9	10

Knowledge (content)						4(2)	1(1)	1(2)		4(3)
Skills	1	1	1	2		2	(3)	2(3)	(1)	1(1)
Practical work	(1)	1(1)	(1)	2	3(1)	1(2)	(2)	2		1

ANNEXURE E INSTRUCTION SHEET

Information about the test

1. Only multiple-choice items appear in the test.
2. The items test for certain Physical Science concepts, skills and knowledge.
3. Test scores will only be used for my research purposes.
4. This is a trial entry-level test and all responses will be analyzed statistically for research purposes only.
5. Thank you for the contribution you are making.

Thank you

Samiega Davids

Instructions

1. Please fill in your details on the answer sheet.
2. Choose the most correct answer for each item.
3. There is only one correct answer for each item.
4. You may use a calculator.
5. Please do not guess.
6. Negative marking will be applied.
7. Formulae and Physical constants are included for your use.
8. Time for test: 1 hour.

ANNEXURE F ANSWER SHEET

Name and Surname : …….…….

Last school attended : ……...

Student number : ……..

Course enrolled for at Technikon : ……..

Home language : …….

Date of Test : ……..

Please put your answer next to the number : eg. 1a , 2d ,etc.

1…..	2…..	3…..	4…..	5…..	6…..
7…..	8…..	9…..	10….	11….	12….
13….	14….	15….	16….	17….	18….
19….	20….	21….	22….	23….	24….
25….	26….	27….	28….	29….	30….
31….	32….	33….	34….	35….	36….
37….	38….	39….	40….		

ANNEXURE G PILOT TEST C1

1. According to the graph: if the value of A should increase, the value of B will …

a. also increase
b. decrease
c. remain the same
d. none of the above
e. increase and then decrease

2. How many moles of nitrogen are contained in 2 moles of hydrazoic acid, HN

a. 1
b. 2
c. 3
d. 4
e. 6

3.How many moles of oxygen, hydrogen and magnesium each combine to form magnesiumhydroxide,
Mg (OH).

	O	H	Mg
a.	1	1	1
b.	1	2	1
c.	2	2	1
d.	2	2	2
e.	1	2	2

4. Suppose that the total pressure on a mixture of helium and argon is 745 pressure units and that the partial pressure of helium is 640 pressure units.
If all of the argon is removed from the sample, but the volume of the container was left the same and the temperature was not changed: what would a pressure gauge read in pressure units for the remaining gas?

a. 101,3
b. 105
c. 640
d. 745
e. none of the above

5. Lowry – Bronsted regarded an acid as a substance which

a. dissolves readily in water

b. accepts protons
c. forms hydroxyl ions (OH) in aqueous solution
d. forms hydrogen ions (H) in aqueous solution
e. donates protons

6. Which reaction will produce H(g) fastest?

a. HCl (conc) + Mg (ribbon) MgCl (aq) + H (g)
b. HCl (dil.) + Mg (ribon) MgCl (aq) + H (g)
c. HCl (conc) + Mg (powder) MgCl (aq) + H (g)
d. HCl (dil.) + Mg (powder) MgCl (aq) + H (g)

7. During a titration experiment you obtain the following readings:

first reading	21,5ml
second reading	20,8ml
third reading	20,6ml
fourth reading	20,7ml

Which reading should be used in the calculation

a. 20,6 ml
b. 20,7 ml
c. 20,8 ml
d. 20,9 ml
e. 83,6 ml

8. If [H]. [OH] = 10 and [OH] is 0,5mol/dm calculate the [H] in mol/dm .

a. 0,5 x 10
b. 2 x 10 -14
c. 0,5
d. 2 x 1014
e. none of the above

9. In the reaction M + N M + N

M is the oxidising agent because it loses electrons
M is the reducing agent because it loses electrons
N is the oxidising agent because it gains electrons
N is the reducing agent because it gains electrons

a. Only (III) is correct
b. only (I) and (IV) are correct
c. only (II) and (III) are correct
d. only (I) and (III) are correct
e. only (II) and (IV) are correct

10. The graph depicts the progress of a chemical reaction against the potential energy. The labels of the diagram are as follows:

I reactants
II activation energy
III activated complex
IV products
V heat of reaction

The correct one(s) is / are:

a. I , II , IV
b. I , III , IV
c. I , IV , V
d. I , II , V
e. I , III , V

11. How does the average kinetic energy of molecules change during an exothermic reaction

a. decreases because the system warms up
b. increases because the system warms up
c. decreases because the system cools down
d. increases because the system cools down
e. does not change

12. During an exothermic reaction

a. heat is released by the system
b. heat is used by the system
c. more heat is released than used by the system
d. more heat is used than released by the system
e. heat of reaction , H has a positive value

13. A certain mass of gas has a volume of 10dm at a temperature of 293K and standard pressure. If the temperature of the gas remains constant and the pressure is halved, the gas will have a volume of ……dm

a. 2,5
b. 5
c. 10
d. 20
e. 40

14. The conjugated acid – base pair in the reaction is

NH (g) + H O (l) NH (aq) + OH (aq)

a. H2O (l) and OH (aq)
b. NH (g) and H O (l)
c. NH (aq) and OH (aq)

d. H O (l) and NH (aq)
e. NH (g) and OH (aq)

15. Study the two graphs I and II, then choose the correct option(s)

(i) Graph I shows direct proportionality with A increasing as B increases
(ii) Graph II shows direct proportionality with A increasing as B increases
(iii) Graph I shows inverse proportionality with A increasing as B decreases
(iv) Graph II shows inverse proportionality with A increasing as B increases

a. Only (i) is correct
b. Only (ii) is correct
c. only (i) and (iii) are correct
d. only (i) and (iv) are correct
e. only (ii) and (iv) are correct

16. The number of hydrogen atoms in 2g H (g)
(relative atomic mass : H = 1)

a. 1
b. 2
c. 4
d. 6,023 x 10
e. 1,2 x 10

17. A solution contains 15g of KOH dissolved in 250ml of water. The concentration of the solution in mol/dm is...
(Relative atomic mass: K = 39 O = 16 H = 1)

a. 0,93
b. 1,07
c. 2
d. 3,75
e. 60

18. If [H].[OH] = 10 and [H] = 0,001 mol/dm .Calculate the pH of the solution.

a. 2,7
b. 3
c. 11
d. 12
e. 14

19. Consider the reaction and choose the correct option

Cl + I Cl + I

	substance oxidised	substance reduced	oxidising agent	reducing agent
a.	Cl	I	Cl	I
b.	I	Cl	I	Cl
c.	I	Cl	Cl	I
d.	Cl	I	I	Cl
e.	Cl	Cl	I	I

20. If an experiment calls for 0,5mol ZnS, how many grams of ZnS do we have to weigh out?
(relative atomic mass : Zn = 65 S = 32)

a. 0,5
b. 24,25
c. 48,5
d. 97
e. 194

21. The reaction represented by the following equation is in equilibrium.

2SO + O 2SO + heat

If heat is applied to the above system:

a. the moles of the product remain constant
b. the concentration of SO in the equilibrium mixture increases
c. the equilibrium will shift to the right
d. the moles of the product increase
e. none of the above

22. In an electrochemical cell (galvanic cell) the following occur:

a. anions move to the anode where oxidation occur
b. anions move to the cathode where oxidation occur
c. anions move to anode where reduction occur
d. anions move to the cathode where reduction occur
e. anions move to the cathode where redox reaction occur

23. Which is the correct structure for 3 - hexene

a. (i) and (ii)
b. (i) and (iii)
c. (iii) and (iv)
d. (ii) and (iv)
e. (i), (ii) and (iii)

24. Sodium combines with chlorine to form NaCl according to the following equation:

2Na (s)	+	Cl (g)		2NaCl(s)
(2 x 23)g		(2 x 35)g		(2 x 58)g

How many grams of Na are needed to make 29g NaCl

a. 11,5
b. 23
c. 29
d. 46
e. 92

25. The following reaction occurs spontaneously in an electrochemical cell (galvanic cell):

Cu (aq) + Zn (s) Zn (aq) + Cu (s)

Which half–reaction occurs in the cathode compartment.

a. Cu (s) Cu (aq) + 2e
b. Cu (aq) + 2e Cu (s)
c. Zn (s) Zn (aq) + 2e
d. Zn (aq) + 2e Zn (s)
e. Cu (aq) + Zn (s) Zn (aq) + Cu (s)

26. A student performs an experiment to illustrate Boyle's Law. She obtains the following results:

	p (kPa)	V (m)
1.	101,3	0,2
2.	120	0,169

Which volume (in m) can she expect at a pressure of 200kPa ?

a. 0.039
b. 0,101
c. 0,2
d. 0,369
e. 9,87

27. Study the following compounds. Decide whether they are isomers or identical AND what their functional groups are

I : CH OCH CH II : CH CH CH OH

	Functional groups I	II
a. isomers	OH	C O
b. isomers	C O C	OH
c. identical	OH	OH
d. identical	C O	C O
e. identical	OH	C O

28. Write the condensed formula for the product of the following reaction

The addition of water to ethene

a. C H
b. C H O
c. C H
d. C H O
e. C H O

29. By using the redox – tables, balance the following reaction:

MnO + Sn Mn + Sn

ANNEXURE H PILOT TEST C2

Data you may need when answering the questions.

Avogadro's constant	**N_A or L**	**6.02×10^{23} mol**
Standard temperature	**T**	**273K**
Standard Pressure	**p**	**101.3 kPa**

A Periodic Table is included at the end of this test paper.

1. Mole of sodium Na = 23g. How many moles is 5g Na?

a. 0.2
b. 4.6
c. 5
d. 23
e. 115

2. The formula mass of Li**2**O is … [Li = 3g/mol; O = 16g/mol]

a. 13
b. 19
c. 21
d. 22
e. 48

3. Which conversion is correct?

	ml	cm^3	dm^3	l
a.	250	0.25	0.25	250 000
b.	250	250	0.25	0.25
c.	250	250 000	0.25	0.25
d.	0.25	0.25	250 000	250
e.	0.25	250	0.25	250 000

4.

Which graph represents an endothermic reaction?

a. I because the product has more energy than the reactants
b. II because the product has more energy than the reactants
c. I because the product has less energy than the reactants

d. II because the product has less energy than the reactants
e. Both are endothermic reactions

5. Consider the balanced equation:
$2SO_2 + O_2 \quad 2SO_3$
128g 32g

The mass of SO_3 formed is … (in gram)

a. 32
b. 128
c. 160
d. 256
e. 320

6. Convert 0.2mol/dm^3 to mol/l

a. 0.0002
b. 0.2
c. 20
d. 200
e. 2 000

7. The formula of the product in the reaction is
S + 2e ……

a. S^+
b. S^{2+}
c. S^-
d. S^{2-}
e. S

8. In the container there are two gases (A and B). Gas A exerts a pressure of 200kPa and gas B exerts a pressure of 80kPa. Should gas B be removed from the container whilst the temperature and volume of the container remain the same, gas A will exert a pressure of … in kPa).

a. 20
b. 80
c. 101.3
d. 200
e. 280

9. Boyle's Law states that providing the temperature of a gas is kept constant, the pressure exerted by a gas is …… the volume of the gas.

a. equal to
b. less than
c. greater than
d. direct proportional
e. inverse proportional

10. The notation $_{11}Na$ tells us that

I Na has 11 protons
II Na has 23 electrons
III Na has atomic mass of 23
IV Na has 12 neutrons

The correct option(s) is/are:

a. I and II
b. II and IV
c. I and III
d. IV only
e. I, III and IV

11. Consider the following ions: Na^{+}; O^{2-}; Ca^{2+}; Cl^{-}
They can combine as follows:

a. CaCl and NaCl
b. NaO and CaO
c. CaCl and Na_2O
d. $NaCl_2$ and CaO
e. $CaCl_2$; Na_2O and CaO

12. Should water (H_2O) act as a base the product will be:

a. H_2O
b. H_3O^{+}
c. OH^{-}
d. H_2O_2
e. H_2O cannot act as a base

13. The effect of a catalyst in a chemical reaction is that it ….

a. increases the energy level of the reactants
b. increases the energy level of the products
c. decreases the energy level of the reactants
d. decreases the energy level of the products
e. decrease the activation energy of the reaction

14. The alkane in the following is

15. The electron-dot-notation shows the number of electrons in the outer energy layer of the atom. The correct notation is

a. Be

b. F

c. C

d. Na

e. Li

16. The formula of lead (IV) oxide is

a. Pb_4O
b. PbO_4
c. Pb_2O
d. PbO_2
e. PbO

17. The formula of the product in the reaction is:

Mg ……. + 2e

a. Mg^{+}
b. Mg^{2+}
c. Mg^{-}
d. Mg^{2-}
e. Mg

18. When a gas is heated the

I average kinetic energy of the gas particles decreases
II average velocity of the gas particles increases
III gas particles will collide more often with each other

The correct option(s) is/are:

a. I
b. II
c. III
d. I and II
e. II and III

19. The option(s) in question 18 that will lead to an increase in pressure is/are:
a. I
b. II
c. III
d. I and III
e. II and III

20. 1 Mole of KCl = 74g. To make up a KCl – solution of 0.5mol/dm^3 you need …. gram of KCl in 1dm^3 distilled water.

a. 0.5
b. 37
c. 39
d. 74
e. 148

21. I_2 (s) will dissolve in

a. water because it has a polar bonding
b. $KMnO_4$ – solution because of its ionic nature
c. CCl_4 because it is a non – polar solvent
d. Naphthalene because it is a non – polar solute
e. Water because it is a non – polar solvent

22. The pressure that a gas exerts in a container is determined by the

I average velocity of the gas particles
II number of collisions between the gas particles
III average kinetic energy of the particles
IV temperature of the gas particles

The correct option(s) is/are:

a. I and II
b. II and III
c. III and IV
d. Only II
e. All 4 options are correct

23. From the graph we learn that

I real gases have greater volume (V) values at high pressure than ideal gases
II real gases have lower volume (V) values at high pressure than ideal gases
III real gases have the same V- values at high pressure as ideal gases
IV real gases have higher pressure(p) values at low volumes than ideal gases

The correct option(s) is / are:

a. I and III
b. II and III
c. III and IV
d. Only IV
e. I and IV

24. Which one of the following is the balanced equation?

a. Sn^{4+} Sn^{2+}
b. KOH + HCl KCl + H2O
c. KCl + H_2SO_4 K_2SO_4 + HCl
d. Mg + H_2O $Mg(OH)_2$ + H_2
e. 2Li + O_2 Li_2O

25. If H stands for the <u>difference</u> in the potential energy between the reactants and the product during a chemical reaction, then H in …

a. I has a positive value
b. II has a positive value
c. I has a negative value
d. Both have positive values
e. Cannot be determined from graphs

26. Study the two reactions and then answer the question

$HSO_4 + H^+$ H_2SO_4
HSO_4 $SO_4 + H^+$

The role of HSO_4 in both reactions is that of a

a. base
b. acid
c. ampholyte
d. oxidising agent
e. reducing agent

27. A redox reaction includes a

I transfer of protons
II transfer of electrons
III oxidation reaction
IV reduction reaction

The correct option(s) is / are:

a. I
b. I and II
c. II and IV
d. III and IV
e. II , III and IV

28. The functional group of the alcohols is

a. C – O - C
b. C – C
c. C = C
d. COOH
e. OH

29. If H_3PO_4 should lose two H^+ - ions one of the products will be:

a. HPO_4
b. H_2PO_4
c. HPO_4
d. H_2PO_4
e. H_3PO_4

30. The valency of oxygen in copper (I) oxide is:

a. –2
b. –1
c. 0
d. 1+
e. 2+

31. You are given that c = n/V and that n = m/M. By combining the two equations another equation for c will be:

a.c = VM/m
b.c = V/Mm
c.c = M/Vm
d.c = Mm/V
e.c = m/MV

32. Study the following reactions carefully and decide which reactant A, B, C or D is the most reactive.

B + KA	KB + A
B + KC	no reaction
D + KA	KD + A
D + KB	KD + B

a. A
b. B
c. C
d. D

33. Give the concentration of 4,5g/dm^3 NaCl in mol/dm^3. Given that: M(NaCl) = 58g/mol.

a. 0.25
b. 0.5
c. 1
d. 14.5
e. 58

33. A solute will dissolve in a solvent only if …

a. both have polar bonds
b. one has a polar and the other has a non – polar bond
c. one is ionic and the other a non - polar
d. one is a solute and the other a solvent
e. both are solvents

35.

By decreasing the volume of the container as in B, the pressure in B will:

a. decrease because the volume decreased
b. decrease because the molecules have less space to move in
c. increase because the molecules will collide more often
d. increase because the molecules will collide less
e. remain constant

ANNEXURE G PILOT TEST P1

1.Select the quantity that matches the size of the following items the closest: length of a small brick; width of a road; length of an ant:

	Length of Brick	width of road	length of ant
a.	30mm	7 cm	4 m
b.	30 cm	7 m	4 mm
c.	30m	7 mm	4 cm
d.	30mm	7 m	4 cm
e.	30cm	7 mm	4 m

2. In the diagram below X and Y are two spring balances of no mass. A weight of 20N is suspended from Y. The reading on the balances will be as follows:

a. X is greater than Y
b. Y is greater than X
c. X and Y are the same
d. X is double that for Y
e. Y is double that for X

3. A charge q exerts a force of 1,9 x 10 N on a second charge q (see sketch). What is the magnitude of the force that q exerts on q .

a. 0
b. 9,5 x 10 N
c. –9,5 x 10 N
d. 1,9 x 10 N
e. –1,9 x 10 N

4. The total mechanical energy of an object is determined by its

a. mass
b. velocity
c. mass and velocity
d. height above zero – potential
e. kinetic as well as potential energy

5. How long would it take a racing car to increase its speed from 10m/s to 30m/s if it does so with constant acceleration over a distance of 80m?

a. 2s
b. 4s

c. 5s
d. 8s
e. cannot be calculated since acceleration is not given

6. The force needed to move an object of mass 20kg vertically upwards against gravity with an acceleration of 2m/s is:

a. 5N
b.10N
c. 40N
d. 200N
e. 240N

7. The globes A, B and C in the circuit are identical. If globe C burns out, then the brightness of A

a. remains unchanged
b. decreases because the total resistance of the circuit increases
c. increases because there are fewer globes in the circuit
d. increases because the total resistance is less
e. none of the above

8. From the graph determine the distance travelled in 20s.

a. 4m
b. 40m
c. 100m
d. 1 000m
e. 2 000m

9. Charges X, Y and Z are arranged in an equilateral (all sides equal) triangle. The relative magnitude of the charges are given as:
X = +1C Y = -2C Z = +2C

Draw the direction of the electrostatic forces acting on charge X and determine the direction of the resultant electrostatic force on charge X.

10. Three identical resistors are connected as shown. The resistance of the connecting wires as well as the internal resistance of the battery is small and can be ignored. The readings on ammeters A and A are:

	A	A
a.	3A	3A
b.	3A	6A
c.	6A	3A
d.	6A	9A
e.	9A	9A

11. If you are given that F = and that the distance between the two charges is decreased , then the magnitude of the force , F will

a. Decrease because F 1/r
b. Increase because F 1/r
c. Decrease because F Q Q
d. Increase because F Q Q
e. Remain the same because F

12. If QV/s = mg , then s is equal to

a. mgQV
b. mg / QV
c. mgV / Q
d. QV / mg
e. mgQ / V

13. A point charge of 8 x 10 C is placed near a neutral object. A force of attraction exists between the two objects , because

a. the point charge attracts the neutral object

b. the neutral object's negative and positive particles move to opposite sides of the object
c. the neutral object's positive particles are repelled by the point charge
d. the point charge induces a polarity in the neutral object by attracting the negative particles and repelling the positive particles
e. this is nonsense, because the neutral object has no charged particles

14. A negatively charged oil drop is dropped between two parallel oppositely charged vertical plates (see sketch).The two forces that act on the negatively charged oil drop X are

a. electrostatic to the left, gravity to the right
b. electrostatic to the right, gravity to the left
c. electrostatic upward, gravity downward
d. electrostatic downward, gravity upward
e. electrostatic to the left, gravity downward

15. The north pole of the solenoid is at

a. A
b. B
c. C
d. D
e. E

16. A body of weight 700N is placed 5m high from the floor. The work done is:

a. 140 J
b. 350 J
c. 3 500 J
d. 35 000 J
e. cannot be calculated from the given data

17. The two blocks shown in the diagram slide towards each other along a frictionless table , collide and immediately come to a stop.

During the collision the combined momentum of the blocks

a. is zero

b. remains unchanged
c. decreases
d. increases
e. cannot be calculated from data given

18. From the graph determine the maximum height reached by a stone which is thrown upward .

a. 40m
b. 60m
c. 80m
d. 100m
e. 120m

19. An aircraft comes in to land and touches down on the runway while traveling at 80m/s. The aircraft maintains this speed for 6s. Thereafter it brakes bringing the aircraft to rest with an uniform deceleration of 4m/s. The total length of the runway used during the landing is:

a. 320m
b. 480m
c. 800m
d. 1 280m
e. 51 200m

20. In the circuit the resistors are identical. Study the circuit and give the expected readings on ammeters A and A

	A	A
a.	1	1
b.	1	2
c.	2	1
d.	2	2
e.	2	3

21. Use the following data to plot a graph. What type of graph is it and state the relationship between A and B.

A	2	3	9	14
B	0,5	0,75	2,25	3,5

22. The sketch shows a free – swinging pendulum. The points at which it has maximum values for kinetic and potential energy are:

	K.E.	P.E.
a.	A	B
b.	B	C
c.	B	A
d.	C	B
e.	A	C

23. A force of 17,32 N acts on a 6kg block (see sketch). The block accelerates at 2m/s. Prove that the surface is not frictionless.

24. A model electric motor draws a current of 2A from a 12V source. It takes 4s to lift a 0,8kg mass at constant speed through a distance of 7,2m . Prove that the motor is not working at 100% efficiency.

25. The diagram shows two vectors. The resultant force of their horizontal components is

a. 21,13 N
b. 42,26 N
c. 45,3 N
d. 66,43 N
e. 90,6 N

26. A moving object accelerates from 10m/s to 25m/s. If the mass of the object is 100kg, calculate its gain in kinetic energy.

a. 500 J
b. 1 250 J
c. 5 000 J
d. 26 250 J
e. 31 250 J

27. Use the graph to determine how far the car will have travelled in 10s.

a. 4m
b. 20m
c. 25m
d. 75m
e. 250 m

28. Two boys on roller blades push against each other. Boy A has a mass twice that of Boy B. As a result of the push Boy B moves to the right at 4m/s. The velocity of Boy A will be:

a. 0,5m/s to the left
b. 2m/s to the right
c. 2m/s to the left
d. 4m/s to the right
e. 4m/s to the left

29. A charge of Q = 2 x 10 C and a second charge of Q = 6 x 10 C is placed near each other . The magnitude of the force that Q exerts on Q is

a. smaller than what Q exerts on Q
b. greater than what Q exerts on Q
c. equal to what Q exerts on Q
d. in the same direction as what Q exerts on Q
e. equal to what Q exerts on Q , but in the opposite direction

ANNEXURE H PILOT TEST P2

Data you may need in answering the questions.

$v = u + at$	$P.E. = mgh$
$s = \frac{(u+v)t}{2}$	$K.E. = 1/2mv^2$
$F\ t = m\ v$	$W = Fs$
$p = mv$	$P = W/t$
$Fres = ma$	$g = 10m/s^2$
$E = F/Q$	$E = kQ/r^2$
$V = W/Q$	$E = V/d$

1. The 4kg – body is stationary. The force(s) working on the 4kg – body is / are:
I gravitational force upward
II gravitational force downward
III tension in rope upward
IV tension in rope downward

Your option(s) is / are:

a. I
b. II
c. III
d. I and IV
e. II and III

2. A free – falling body hits the ground at 7m/s. The mass of the body is 0.5kg. The kinetic energy of the body when it hits the ground is

a. 1.75J
b. 3.5J
c. 7.5J
d. 12.25J
e. 35J

3. The sketch shows a free–swinging pendulum. The points at which it has maximum values for kinetic and potential energies are:

	K.E.	P.E.
a.	A	C
b.	B	C
c.	B	A
d.	C	B
e.	C	A

4. A boy is able to push a box with a force of 100N 20m far in 5s. The work done by the boy is ……..(in Joules)

a. 100
b. 400
c. 500
d. 2 000
e. 10 000

5. The power of the boy in question 4 is … in Watt)

a. 25
b. 400
c. 500
d. 2 000
e. 10 000

6. A neutral object has

a. no charged particles
b. only neutrons
c. equal amounts of neutrons and protons
d. equal amounts of neutrons and electrons
e. equal amounts of electrons and protons

7. A positively charged particle is placed near a neutral object.

a. there is no force between them
b. the two objects will repel each other
c. the two objects will attract each other
d. initially they will repel each other, but afterwards they will attract each other
e. initially they will attract each other , but afterwards they will repel each other

8. The force needed to keep the object in equilibrium is

a. 5N to the left
b. 5N to the right
c. 6N up
d. 11N up
e. 11N to the left

9. When speaking about the " rate of " something, as in the "rate of work done ", what factor is always involved?

a. energy
b. momentum
c. time
d. resistance
e. mass

10. What is the magnitude of the horizontal and vertical components of the vector respectively in the diagram?

	HC	VC
a.	0	4
b.	4	6
c.	6	4
d.	6	0
e.	6	6

11. By moving from A to B (see sketch), the player has in essence moved

I east
II north
III south
IV west

The correct option(s) is/are:

a. I
b. II
c. II and IV
d. III
e. IV

12. A student applies a force of 200N to objects of different mass. As the mass of the objects increases, the … thereof will decrease.

a. force
b. work done
c. time
d. acceleration
e. weight

13. At which point will a charge experience the greatest force?

a. P
b. Q
c. R
d. S
e. T

14. You are given that F 1/m. This means that …….

a. if the value of m increases , the value of F will also increase
b. if the value of m decreases , the value of F will increase
c. F is directly proportional to m
d. F is equal to 1/m
e. F is equal to m

15. The force needed to pull the ball upward at an acceleration of $2m/s^2$ is:

a. 4N
b. less than 4N
c. equal to 20N
d. more than 20N
e. none of the above

16. The charge X experiences a force of
I attraction towards Z
II attraction towards Y
III repulsion away from Z
IV repulsion away from Y

The correct statement(s) is / are :

a. I
b. II and III
c. III
d. IV

e. I and IV

17. The resultant of the force(s) acting on X in question 16 can be drawn as:

18. In the diagram the bulbs A, B and C are identical. If bulb C blows, then

I B is connected in parallel with A
II B is in series with A
III A will get more current than B
IV A and B will get the same current

The true statement(s) is/ are :

a. II and IV
b. III
c. II and III
d. I
e. I and IV

19. If bulb C in question 18 blows , then the

I total resistance of the circuit has increased
II total current is unchanged
III current flowing through the circuit will be less
IV current flowing through the circuit will be more

The true statement(s) is / are :

a. I
b. I and III
c. III
d. I and IV
e. I and II

20. If you add the horizontal components of the two vectors in the sketch together, their resultant will be :

a. 100N
b. 200N
c. less than 100N
d. between 100N and 200N
e. more than 200N

21. Trolleys A and B are stationary. When the spring between them is released, the trolleys move in opposite directions. Given the data below, determine the velocity at which B will move.
The velocity of B is :

a. half the velocity of A
b. twice the velocity of A
c. equal to the velocity of A
d. four times the velocity of A

e. cannot be determined

22. What is the combined momentum of the trolleys in question 21 after separation (in Ns)?

a. 0
b. 0.5
c. 1
d. 2
e. 4

23. A body of mass 20kg is lifted 15m high from the floor. The work done (in Joules) is

a. 300
b. 450
c. 2 250
d. 3 000
e. 6 000

24.

The above v/t graph shows the movement of a stone thrown vertically upward and which is allowed to return to its original position. From the graph we know that the :
I stone moves upward in the first 4 s and downward in the last 4 s.
II maximum height of the stone is reached at 4s
III distance up is equal to the distance down
IV maximum height is reached at 8s
The correct option(s) is / are :

a. I and II
b. III and IV
c. I and IV
d. II and III
e. I, II and III

25. From the graph in question 24 we know that the
I maximum height reached by the stone is 40m
II total distance covered by the stone is 80m
III maximum height reached by the stone is 20m
IV total distance covered by the stone is 40m

The correct option(s) is / are:

a. I
b. I and II
c. III
d. III and IV
e. IV

26. A car travels at 15m/s and reduces speed over 10s until it reaches a speed of 8m/s. Its acceleration in m/s^2 is :

a. –0.7
b. 0.7
c. –2.3
d. 2.3
e. 23

27. Between which two points exist the greatest potential difference?

a. a-b
b. a-c
c. a-d
d. a-e
e. a-f

28. The graph of v/t depicts the motion of a car.

The car is:
a. accelerating
b. decelerating
c. moving at constant speed
d. moving at uniform acceleration
e. standing still

29. In which direction should a third force pull in order for the object to remain in rest (not moving)?

30. An object is pulled to the right over a rough surface. How many forces are acting on the object?

a. 1
b. 2
c. 3
d. 4
e. 5

31. In the diagram which arrow shows the weight of the block?

a. a
b. b
c. c
d. d
e. e

32. The rate of work done refers to …

a. kinetic energy
b. potential energy
c. power
d. mass
e. acceleration

33.Consider the following system of forces. The two masses hang over a frictionless pulley. The system moves to the left with an acceleration of $1m/s^2$. What is the relation between the forces F and T?

I F < T
II F > T
III F = T

The correct option(s) is / are:

a. I
b. II
c. III
d. I and III
e. II and III

34. According to Coulomb's Law F $(Q_1.Q_2)/r^2$.
I If the charges Q_1 and Q_2 are increased, the force F will also increase
II If the value of r is increased, the value of F will also increase
III If the distance r is decreased , then the force F will increase

The correct statement(s) is / are:

a. I
b. II
c. III
d. I and II
e. I and III

35. The combined momentum of two bodies is 40Ns to the RIGHT. If the bodies separate and body A has a momentum of 6Ns to the LEFT upon separation, the momentum of body B must be:

a. 6 Ns to the right
b. 34Ns to the right
c. 34Ns to the left
d. 46Ns to the right
e. 46Ns to the left

36. A ball held 10m high has a potential energy of 10J. The mass of the ball is …

a. 0.1kg
b. 1kg
c. 10 kg
d. 100 kg

e. 1 000 kg

37. The two forces keeping the negatively charged oil drop stationary between the two oppositely charged parallel plates are : F = QE (up) = mg (down). If the charge Q on the oil drop is increased , the oil drop will ……

a. remain still
b. move up
c. move down
d. move up initially and then come down
e. first move down and then move up

38. The v/t graph shows the movement of a car. What is the velocity of the car at 2s (in m/s)?

a. 0
b. 2
c. 4
d. 7.5
e. 15

39. Study the sketch. The trolley is moving …

a. at constant velocity
b. at constant acceleration
c. slower
d. east
e. west

40. Which ticker tape best presents the movement of the trolley in question 39?

41. The area under this graph gives the distance travelled by the car. The distance is (in metres) …

a. 30
b. 40
c. 50
d. 60
e. 70

ANNEXURE I PILOT TEST T1

Formulae and physical constants

$W = Fs$	$P = W/t$
$c = m/(MV)$	$F = kQ_1Q_2$
$p_1V_1 = p_2V_2$	$K_w = 1 \times 10^{-14}$

1. Mass is a scalar quantity because it

a. has magnitude only
b. has direction only
c. has magnitude and direction
d. mass is not a scalar quantity
e. tells you how heavy you are

2. 1N is equal to

a. 1kg.m.s
b. 1kg.m/s
c. 1kg.m/s^2
d. 1kg.m^2/s
e. 1kg.m^2/s^2

3. The following are the units for which quantity

newton.meter	volt.coulomb	joule
Nm	VC	J

a. momentum
b. displacement
c. resistance
d. work done
e. impulse

4. A conductor has …… if the current therein is 1A when a potential difference of 1V is maintained between its ends.

a. a charge of 1 C
b. a time of 1 sec
c. an electrical energy of 1 J
d. a resistance of 1
e. an electrical consumption of 1kWh

5. 1Volt is equal to

a. P/I
b. RQ
c. W/t
d. I^{2}Rt
e. It

6. The element that is studied in Organic Chemistry is

a. nitrogen
b. oxygen
c. carbon
d. sulphur
e. phosphorous

7. The following reaction occurs in an electrochemical cell
$Cu^{2+}(aq) + Zn(s) \qquad Cu(s) + Zn^{2+}(aq)$

One of the half - reactions for this cell is:

a. $Cu(s) \qquad Cu^{2+}(aq) + 2e$
b. $Cu^{2+}(aq) + 2e \qquad Cu(s)$
c. $Zn^{2+}(aq) + 2e \qquad Zn(s)$
d. $Cu^{2+}(aq) + Zn(s) \qquad Zn^{2+}(aq) + Cu(s)$
e. $Zn(s) + 2e \qquad Zn^{2+}(aq)$

8. A boy is able to push a box with a force if 100N, 20m far in 5s. The power of the boy (in watt) is

a. 25
b. 400
c. 500
d. 2 000
e. 10 000

9. A standard solution always has a

a. concentration of 1 mol/dm^3
b. concentration of 1 g/dm^3
c. concentration of 1 mol/dm^3 at 25^0C
d. concentration of 1 g/dm^3 at 25^0C
e. precisely known concentration

10. In the reaction: $M^{2+} + 2e \qquad M$, M^{2+} gains two electrons. This means that M^{2+} is

a. oxidised
b. reduced
c. the reducing agent
d. neutralised
e. none of the above

11. When the gas NO_2 is placed on ice it changes to a lighter colour. The formula of the lighter coloured gas is

a. NO
b. NO_2
c. N_2O
d. N_2O_4
e. NO_4

12. The dissociation of HCl, a strong acid, can be written as follows:
$HCl + H_2O \qquad H_3O^+ + Cl^-$

What can you expect at equilibrium?

a. a high concentration of HCl
b. a high concentration of H_2O
c. a high concentration of H_3O^+
d. a low concentration of Cl^-
e. all four will have the same concentration

13. The ionic product, or ionization constant of water, Kw, at 25^0C is

a. 0
b. 10^{-7}
c. 10^{-14}
d. 10^7
e. 10^{14}

14. When using the formula pV = nRT, the unit for T is

a. K
b. F
c. ^{0}C
d. sec
e. hour

15. The table shows how a piece of zinc disappears when reacted with hydrochloric acid.

Time in min.	0	2	4	6	8	10	12
Mass of zinc	5	4	3,5	2,9	2,6	2,5	2,5

A graph of the results will look like:

16. Tyron is trying to find out how much solid is dissolved in a sample of river water. The pictures show the stages in the method of his experiment, but they have been jumbled up. The correct order of the stages is

a. A-B-C-D-E-F
b. C-E-B-A-F-D
c. C-E-D-F-A-B
d. C-E-B-D-A-F
e. C-D-E-F-A-B

17. You are asked to connect two 1ohm bulbs in series with an ammeter and a 1,5volt battery. If you have followed the instructions your circuit should look like:

18. When heating liquid in a test tube one should take care to

a. heat at one spot on the test tube only
b. heat the bottom of the test tube
c. heat from the top to the bottom of the test tube
d. look into the test tube whilst heating to check that everything is fine
e. direct the test tube at your partner so he / she can observe the reaction

19. The bar graph shows in which habitat wood lice prefer to live.

Wood lice prefer to live in …

a. wet stones
b. dry leaves
c. dry stones
d. wet sand
e. wet surroundings

20. The sketches show the temperature readings students are required to take in order to complete the table. Which student recorded the data correctly?

	Start T	Final T	Change in T
Student 1	6	4,5	4,5
2	6	4,5	1,5
3	6	4,5	2,5
4	7	5,5	1,5
5	7	5,5	5,5

a. 1
b. 2
c. 3
d. 4
e. 5

21. Abby investigated the relationship between acceleration and force (mass was kept constant). She recorded the following results:

F (N)	a (m/s^2)
2	1
4	2
6	3

This means that
a. F=a
b. F < a
c. F a
d. F 1/a
e. 1/F a

22. During an experiment a trolley is placed on a frictionless, horizontal surface and is pulled by elastic bands. The mass of the trolley is changed by placing masses on it. From the

graphs below, select the one which best describes acceleration versus mass of trolley when pulled by a constant force.

The correct graph is
a. 1
b. 2
c. 3
d. 4
e. 5

23. The vector v_3 in the diagram is equivalent to

a. $v_1 - v_2$
b. $v_1 + v_2$
c. $v_2 - v_1$
d. $v_1^2 + v_2^2$
e. v_1 cos

24. When performing the experiment depicted in the sketch, which rule are you investigating?

1. sine rule
2. paralellogram rule
3. triangle rule
4. vector rule

The correct rule (s) is /are:

a. 1, 2
b. 3, 4
c. 1, 4
d. 2, 3
e. 2, 4

25. When preparing a standard solution the volumetric flask should be filled with distilled water to the mark

a. after you have dissolved the salt in half the water
b. before you add the salt
c. fill with water till pass the mark
d. you are allowed to ignore the mark
e. none of the above

26. During standardization of a dilute solution of acid with a dilute solution of base the pH at the time of colour change is

a. 1
b. 2
c. 7
d. 13
e. 14

27. A student took readings of the volume of a fixed mass of gas, maintaining the temperature constant while he changed the pressure. He made an error in one of the volume readings. Which volume reading is incorrect?

His results were:

	Volume cm^3	Pressure kPa
a	240	600
b	180	800
c	144	1000
d	108	1200
e	90	1600

28. Which pair of experiments would you use to find out the effect of the concentration on the rate of reaction

a. 1,2
b. 1,3
c. 1,4
d. 2,3
e. 3,4

29. Equilibrium exists between the blue $CoCl_4^{2-}$ and the light pink $Co(H_2O)_6^{2+}$. To change the colour of the mixture to blue, you can

$CoCl_4^{2-} + 6H_2O \qquad Co(H_2O)_6^{2+} + 4Cl^- + heat$

a. use a bigger container
b. cool off mixture
c. add H_2O
d. add a few ice cubes to mixture
e. heat mixture

30. The distance between two point charges, $Q_1 = 1,2 \times 10^{-10}C$ and $Q_2 = 2,4 \times 10^{-12}C$, which experience a force of $F = 2 \times 10^{-3}N$, is … $k = 9 \times 10^9 Nm^2/C^2$)

a. $1,44 \times 10^{-19}$m
b. $1,3 \times 10^{-9}$ m
c. $3,6 \times 10^{-5}$ m
d. $2,8 \times 10^{4}$m
e. $7,7 \times 10^{8}$ m

31. For the Gas Laws pressure is measured in Pa or

a. atmospheric pressure
b. 101,3kPa
c. N/m^2
d. Nm^2
e. m^3

32. An experiment was carried out to compare how far three wound - up cars would travel. The results are in the table.

	Distance traveled in each second		
	Car 1	Car 2	Car 3
1st second	4,6	8,71	1,9
2nd second	4,1	7,94	1,4
3rd second	3,3	6,46	0,71
4th second	2,3	4,33	0,1
5th second	0,3	1,12	0,0

During which second did all three cars cover the greatest distance?

a. 1st second
b. 2nd second
c. 3rd second
d. 4th second
e. 5th second

33. If the force, F which is applied to a trolley is ……(I)…… , its acceleration will …….(II)……. , provided its mass is kept constant .

	(I)	(II)
a.	increased	increase
b.	decreased	increase
c.	decreased	stay the same
d.	increased	decrease
e.	kept constant	increase

34. Two forces T_1 and T_2 are working on the same body. (see sketch).You want to determine the resultant of the two forces graphically .The direction of the resultant is

a. north
b. east
c. south
d. west
e. northeast

35. The dissociation of water occurs according to the reaction

$$H_2O + H_2O \quad H_3O^+(aq) + OH^-(aq)$$.

At 25^0C and equilibrium the $[H_30^+] = [OH^-] = \ldots\ldots\ldots\ldots\ldots$ mol/dm^3

a. 10^{-14}
b. 10^{-4}
c. 10^{14}
d. 10^{-7}
e. 10^7

36. The SI - unit for distance can be either

	A	B
a.	mm	cm
b.	cm	m
c.	m	km
d.	cm	km
e.	km	mm

37. You have to prepare a 500 cm^3 oxalic acid solution with concentration of 0,1 mol/dm^3. You are given that formula mass of oxalic acid = 126 g/mol. What is the mass of the oxalic acid needed to make up the solution?

a. 3,15g
b. 3,34g
c. 6,3g
d. 12,6g
e. 25,2g

38. For a neutralization experiment the class is instructed to fill the burette with the dilute alkali and the beaker with dilute acid and phenolphthalein. The different groups reported the following results. Which group followed the correct instructions?

Groups	Colour in beaker at the start	Colour in beaker at the end of reaction
a	pink	blue
b	blue	pink
c	clear	pink
d	pink	clear
e	yellow	blue

39. The measured values of pressure, p and volume, V as obtained in an experiment were plotted as shown below. Which one of the following relationships best fit the experimental results?

a. p V
b. p V^2
c. p 1/V
d. p $1/V^2$
e. V $1/p^2$

40. You have to decide which of three machines is the most efficient. Their data is given in the table. What would you add to this table to make the comparison easier?

	energy put in	energy got out
push bike	500J	400J
tube train	100MJ	50MJ
car engine	200kJ	50Kj

1. add column with difference in energy in / out
2. change all units to J
3. add column with % efficiency worked out
4. it is not necessary to add more information

a. 1
b. 2
c. 3
d. 4
e. 1,2

ANNEXURE J PILOT TEST T2

Formulae and physical constants

$W = Fs$	**$g = 10\ m/s^2$**
$V = IR$	**$R = r_1 + r_2 + r_3$**
$F = kQ_1Q_2$	

1. A scalar is a quantity with

a. direction only
b. magnitude only
c. velocity
d. magnitude and direction
e. velocity and direction

2. One newton is ……

a. the force with which a mass of 1 kg is attracted to the centre of the earth
b. the force acting on a body when it is accelerating at 1 m/s^2
c. the resultant force needed to give a mass of 1 kg an acceleration of 1 m/s^2
d. the weight of a 1 kg mass
e. none of the above

3. Which quantity and its unit are grouped correctly

	Quantity	SI - unit
a.	displacement	m^3
b.	time	s
c.	impulse	Pa
d.	distance	cm
e.	gravity	m / s^2

4. If a current of 1A flows in a conductor when a potential difference of 1V is maintained between its ends, then the resistance of the conductor is

a. 1J
b. 1
c. 1C
d. 1W
e. 1J / s

5. The potential difference between two points in a current - carrying conductor is 1V if 1W of power exists between its two ends and the

a. Work done is 1J
b. charge flowing therein is 1C
c. energy used is 1J

d. current is 1 A
e. current flows for 1min

6. In Organic Chemistry we study

a. carbon and carbon-compounds
b. sulphur and sulphur-compounds
c. nitrogen and nitrogen-compounds
d. halogens and halogen-compounds
e. elements and their compounds

7. In an electrochemical cell experiment the salt bridge is used to

a. connect the two half cells
b. maintain electrical neutrality in the half cells
c. transfer the positive ions
d. transfer of negative ions
e. all of the above

8. A horse pulls a cart with a force of 200 N causing it to move at a constant speed of 6km/h for 30 min.
The work done by the horse is

a. 600J
b. 1 000J
c. 2 000J
d. 36 000J
e. 600 000J

9. A standard solution

a. is prepared at standard conditions
b. has a precisely known concentration
c. is used for standard experiments
d. is used at standard conditions
e. has a concentration of 1 mol/dm^3

10. A substance is reduced when it

a. gains an electron
b. loses an electron
c. gains a proton
d. loses a proton
e. loses a proton and gains an electron

11. The gas NO_2 is in equilibrium at room temperature with

a. NO
b. N_2O
c. NO_4
d. N_2O_4
e. N_4O_2

12. The reaction for the dissociation of water can be written as follows:

$$H_2O(l) + H_2O(l) \qquad H_3O^+(aq) + OH^-(aq).$$

Kw for the reaction is:

a. $[H_2O]. [H_2O]$

b. $[H_3O^+].[OH^-]$

c. $\frac{[H_3O^+].[OH^-]}{[H_20] . [H_2O]}$

d. $\frac{[H_2O].[H_2O]}{[H_3O^+].[OH^-]}$

e. $\frac{[H_3O^+].[OH^-]}{[H_2O]^2}$

13. The dissociation of a strong acid is noted by the fact that

$$HCl + H_2O \quad H_3O^+ + Cl^-$$

a. at equilibrium the concentration of ions is high
b. at equilibrium the concentration of ions is low
c. forward reaction occurs at a slow rate
d. forward and reverse reactions occur at the same rate
e. reverse reaction occurs faster

14. When using the formula pV = nRT , the unit of volume, V, is always

a. cm^3
b. dm^3
c. l
d. m^3
e. mm^3

15. Renaldo adds four metals to a bucket of water. He writes down these observations.

METAL	*OBSERVATIONS*
A	*Bubbles slowly. Metal still there after 60 min.*
B	*Metal disappears in 2 min. Loads of bubbles*
C	*Metal buzzes and goes on fire.*
D	*A few bubbles appear during one hour*

The order of reactivity of the metals, with the MOST reactive FIRST is

a. A-D-B-C
b. B-C-D-A
c. C-B-D-A
d. D-A-B-C
e. C-B-A-D

16. You are asked to draw a flow diagram to explain the process of making a pot of tea. Which order would you follow?
Steps 1. Water in pot
2. tea in pot
3. boil water
4. leave to brew
5. warm teapot

a. 3-1-2-4-5
b. 3-2-1-4-5
c. 3-5-2-1-4
d. 2-3-1-4-5
e. 5-3-1-2-4

17. During an experiment you are asked to connect two 1 - bulbs in series with an ammeter and a 1,5V battery .The table shows the readings the groups got for the ammeter . Which group followed the correct instructions?

Group	Ammeter reading
A	0
B	0,75
C	1,5
D	3
E	3,5

a. A
b. B
c. C
d. D
e. E

18. The safest way to handle a piece of sodium - metal is to

a. use tongs
b. your hands
c. leave it in oil
d. wrap it in a tissue
e. place it in water

19. The table below describes the properties of three minerals that have a very similar appearance.

Mineral	Soluble	Reaction with acid	Hardness
halite	yes	none	2/3
calcite	no	fizzes	2/3
quartz	no	none	7

How would you distinguish one from the other?

a. Quartz is the one that does not react with acid
b. Halite is the one with a hardness of 2/3
c. Calcite is the one not soluble in water
d. Halite is soluble in water
e. You cannot tell them apart because they are too alike

20. Whilst performing an experiment the following could be seen in each of the test tubes.

Bubbles Appear	colour change	rise in temp.	no change	drop in temp.

Five pupils recorded their observations as follows:
reaction; x no reaction

	Pupil	Test tube
		A B C D E
Which pupil is correct?	1	
a. 1	2	
b. 2	3	
c. 3	4	
d. 4	5	
e. 5		

21. When investigating the relationship between acceleration and force (mass is kept constant) the trolley is placed on an incline

a. To make it run fast
b. To overcome friction
c. Because it accelerates better that way
d. Because it is better to apply a force in this position
e. So that everybody can see the trolley

22. A heavier body will accelerate …… …….. than a lighter body, if equal force is applied to both of them.

The missing word(s) is/ are

a. faster
b. slower
c. the same as a
d. at first faster and then slower
e. at first slower and then faster

23. You want to determine the resultant of the two vectors P and Q in the grid. Which diagram shows the correct method of determining the resultant?

a. 1
b. 2
c. 3
d. 4
e. 5

24. During an experiment you have three forces acting on point A. Point A remains stationary .If you draw the three forces, head to tail, what would you find?

a. a resultant force
b. a closed triangle with no resultant
c. three separate vectors
d. a parallelogram of forces
e. a closed triangle with a resultant

25. To prepare a standard solution you need

a. salt and distilled water
b. salt and one litre of distilled water
c. ten grams of salt and a beaker of distilled water
d. a known amount of salt and distilled water
e. one mole of salt and a beaker of distilled water

26. During a standardization experiment a dilute solution of acid is added to 25ml of dilute solution of an alkali with a concentration of 1 mol/dm^3. When is the reaction complete?

a. as soon as the colour change occur
b. once you have added 25ml of the dilute solution of acid
c. once you have added a concentration of 1mol/dm^3 of the dilute solution of acid
d. once you have added all the acid solution
e. as soon as the temperature of the reaction mixture has increased by 1^0C

27. When investigating Boyle's Law you should

a. keep the pressure of the gas constant
b. keep the volume of the gas constant
c. keep the temperature of the gas constant
d. remember to measure the pressure in kPa
e. remember to measure the volume in cm^3 only

28. Look at the drawings. Each drawing shows one way of reacting magnesium with acid.

Put the drawings in order of INCREASING rate of reaction.

a. A-B-C-D
b. B-C-D-A
c. C-D-A-B
d. A-C-B-D
e. D-B-C-A

29. The reaction represented by the following equation is in equilibrium.

$$2SO_2 + O_2 \qquad 2SO_3 + \text{heat}$$

If heat is applied to the system:

a. more SO_2 will be formed
b. more SO_3 will be formed
c. more heat will be formed
d. less O_2 will be formed
e. the equilibrium will not change

30. The force between two point charges of $3{,}2 \times 10^{-19}$C and $1{,}6 \times 10^{-19}$C which are 8×10^{-3}m apart, is …… ($k = 9 \times 10^{9}$ Nm^2/C^2)

a. $2{,}7 \times 10^{-12}$ N
b. $7{,}2 \times 10^{-24}$ N
c. $5{,}8 \times 10^{-26}$ N
d. $4{,}6 \times 10^{-28}$ N
e. 8×10^{-34} N

31. In the diagram there are three charges: X (positive), Y (negative) and Z (positive). A charge can either attract or repulse another. The resultant of the forces acting on X can be drawn as:

32. In the reaction $M + N \qquad M^+ + N^-$

a. M is oxidised
b. M is reduced
c. N is oxidised
d. N is the reducing agent
e. M is the oxidising agent

33. Shaun performed the titration experiment four times and got the following results. Which reading do you think should he use?

first reading	21ml
second reading	20,8ml
third reading	20,6ml
fourth reading	20,9ml

a. 20,6ml
b. 20,8ml
c. 20,9ml
d. 21ml
e. the average of the four readings

34. You are asked to measure the volume of one marble and ten marbles respectively. The steps you can follow are numbered below. Choose the correct sequence of events that you will follow.

Step 1: subtract volume readings from each other
2: place ten marbles in a measuring cylinder
3: divide volume reading for ten marbles by 10
4: measure the volume of water when marbles are also in the cylinder
5: measure the volume of water enough to cover the marbles

a. 5-2-4-1-3
b. 2-5-4-1-3
c. 2-4-5-1-3
d. 2-4-3-5-1
e. 2-4-3-1-5

35. A class learns that all metals conduct electricity and heat and that they are pliable. They are then given an unknown substance, A to test its electrical and heat conductivity and whether it is pliable. They are not told that it is a metal. A - sign indicates a positive reaction and a - sign indicates a negative reaction. Which of the five boys made the right observation for the whole investigation?

	electrical	heat	pliable
a. 1	boy1		
b. 2	boy2		
c. 3	boy3		
d. 4	boy4		
e. 5	boy5		

36. The correct way to dilute an acid

a. pour acid in a beaker and then add some water
b. pour water in a beaker and then add some acid
c. you do not dilute acid you buy dilute acid from the supplier
d. mix equal amounts of acid and alkali
e. mix the acid with twice the volume of alkali

37. Look at the five test tubes A - E. All contain a small piece of magnesium ribbon (the same size in each tube), in excess dilute hydrochloric acid, and produce hydrogen gas. If all the reactions were started at the same time, which will be the second test tube to stop producing hydrogen.

a. A
b. B
c. C
d. D
e. E

38. The diagram shows three forces acting on the same point. The forces are in equilibrium. What is the weight of the stone?

a. 30N
b. 40N
c. 50N
d. 60N
e. 80N

39. A solution of known concentration is called a

a. concentrated solution
b. neutral solution
c. standard solution
d. chemical solution
e. dilute solution

40. When working in a laboratory one should take care to always

a. use only the required amounts of chemicals for an experiment
b. never to pour reagents back into the bottles
c. wipe up spills immediately
d. taste the chemical if you are not sure what it is
e. only a, b and c is true

ANNEXURE K PILOT TEST T3

Formulae and physical constants.

P.E. = mgh **K.E. = ½ mv^2**

P = W/t **$v^2 = u^2 + 2as$**

1. Which representation is that of a scalar quantity?

a. 10s
b.
c. 10Ns up
d. downward pull of 10N
e. 2 m /s north

2. One newton is the unbalanced force which gives a 1kg body

a. A constant speed of 1m/s
b. A constant speed of 2 m/s
c. An acceleration of 1m/s
d. An acceleration of $1m/s^2$
e. An acceleration of $10m/s^2$

3. Power can be measured in J / s or

a. V
b. Pa
c. Nm
d. W
e. K

4. A conductor has a resistance of 1 when a …….i……. flows through the conductor when the …….ii…… is maintained between its ends.

	i	ii
a.	charge of 1C	electrical energy of 1J
b.	power of 1J/s	current of 1A
c.	charge of 1s	electrical energy of 1J
d.	current of 1A	potential difference of 1V
e.	power of 1J/s	current of 1A

5. Potential difference between two ends can be calculated by dividing the power by

a. charge
b. resistance
c. current
d. time
e. work done

6. Which compound will you study in Organic Chemistry?

a. CH_4
b. H_2S
c. NH_3
d. HCl
e. $CuCO_3$

7. Which of the pieces of equipment shown in the diagram is unnecessary for the experiment?

a. the battery
b. the ammeter
c. the voltmeter
d. the source of heat
e. the electrodes

8. A 6kg mass is released from rest at a height of 80m. If air resistance is negligible, its kinetic energy when it has fallen 60m is

a. $4{,}8 \times 10^3$ J
b. $3{,}6 \times 10^3$ J
c. $1{,}2 \times 10^3$ J
d. $1{,}3 \times 10^2$ J
e. ZERO

9. Which of the following is a standard solution?

a. salt solution
b. sugar solution
c. dilute salt solution
d. strong alkaline solution
e. 0,2 mol /dm^3 salt solution

10. What is the definition of reduction?

a. a loss of protons
b. a gain of protons
c. a loss of electrons
d. a gain of electrons
e. a gain of neutrons

11. If the temperature of the glass syringe was raised, which of the following would NOT take place?

N_2O_4 $2NO_2$

a. an increase in the total number of molecules
b. an increase in the weight of gas
c. an increase in the proportion of NO_2 molecules
d. an increase in the intensity of brown colour
e. a decrease in the proportion of N_2O_4 molecules

12. A weak acid does not readily lose its proton(s). At equilibrium you can expect to find:

$$CH_3COOH \qquad CH_3COO^- + H^+$$

a. high [CH_3COO^-]
b. low [CH_3COOH]
c. high [H^+]
d. high [CH_3COOH]
e. equal concentration of all three reactants

13. The reaction for the dissociation of a strong acid is written as follows:

$$HA \qquad H^+ + A^-$$

If $K_c = \frac{[\text{ product }]}{[\text{ reagent }]}$, the K_c - value for the acid will be

a. zero
b. small
c. great
d. 10^{-14}
e. 14

14. In the formula W = Fs, the unit of s can be

a. m or km
b. m or cm
c. cm only
d. m only
e. mm or m

15. You must compare the mass of three objects and find the heaviest of the three. What would you add to / change about the information in order to make the comparison easier?

Given: A = 10mg B = 0,5g C = 0,001kg

You will:
a. not change / add the information
b. divide A 's mass by 1000 to get 0,01g
c. present all three masses in the same unit
d. multiply C's mass by 1 000 to get 1g
e. multiply B's mass by 1 000 to get 500mg

16. The pictures show the various steps one must follow in finding out the volume of ten marbles. Place the steps in the correct order.

a. 1-2-3
b. 1-3-2
c. 2-1-3
d. 2-3-1
e. 3-2-1

17. In order to prepare the gas NO_2, the instructions are to place some copper turnings in a round - bottomed beaker and pour over enough concentrated nitric acid to cover the turnings. Instead of collecting NO_2 you collect a colourless gas, NO.
Where did you go wrong?

You:
a. used too much copper turnings
b. used too much acid
c. used too little acid
d. used too few copper turnings
e. used dilute acid instead of concentrated acid

18. When working with chemicals you should take care to

a. never use a chemical until the teacher has explained its use and precautions to be taken
b. immediately wash with water any part of skin that has been in contact with any chemical
c. never pour reagents back into bottles
d. regard all reagents as poisonous
e. all of the above

19. What is the change in volume in these two examples?

	I	II
a.	$1cm^3$	$5cm^3$
b.	$5cm^3$	$12cm^3$
c.	$6cm^3$	$17cm^3$

d.	$4cm^3$	$7cm^3$
e.	$5cm^3$	$1cm^3$

20. The table shows the average heart rate of some animals. Heart rate is related to the size of the animal. The student made a mistake when he recorded the heart rate of two animals.

Animal	Heart rate
elephant	46
horse	120
human	75
dog	55
cat	240
titmouse	960

Which two animals were recorded incorrectly?

a. elephant and dog
b. horse and human
c. dog and horse
d. cat and horse
e. human and dog

21. You want to investigate the relationship between the acceleration of a trolley and the force applied to it. For the best results you can

a. clean a horizontal surface thoroughly before you do your experiment on it
b. oil the wheels of the trolley
c. do the experiment on an incline
d. only apply a small force
e. do b and c

22. Which trolley will accelerate the fastest?

23. To calculate the resultant of the two vectors AB and BC, the magnitude of the resultant is measured from …….(I)……. and the direction is obtained / drawn from ……..(II)……..

	(I)	(II)
a.	A straight to C	A straight to C
b.	A to B to C	A straight to C
c.	B to C	A straight to C

d.	C straight to A	C straight to A
e.	C to B to A	C straight to A

24. The sketch shows the apparatus used to investigate the relationship between three forces in equilibrium acting at a point. The vector AB is the

a. resultant of the two forces F_1 and F_2
b. equilibrant of the two forces F_1 and F_2
c. resultant of the three forces F_1 , F_2 and F_3
d. equilibrant of the three forces F_1 , F_2 and F_3
e. sum of the forces F_1 , F_2 and F_3

25. Why do we use a volumetric flask instead of a beaker to prepare a standard solution in?

a. it is easier to handle a volumetric flask
b. the beaker is too wide
c. the volumetric flask has a mark to indicate the exact volume
d. you can pour better from the volumetric flask
e. you can dissolve the salt by shaking the flask

26. Below is a diagram of a standardization experiment involving 0,2mol/dm^3 sodium hydroxide solution and dilute hydrochloric acid solution. The aim of this experiment is to

a. determine the concentration of the acid
b. find out whether the alkali can neutralize the acid
c. find out which colour litmus changes into in an acidic solution
d. find out how much acid is needed to neutralize the alkali
e. all of the above

27. The apparatus is used to investigate Boyle's Law. What are the labels?

1	2
a. pressure gauge	volume of gas
b. thermometer	volume of gas
c. thermometer	pressure gauge
d. volume of gas	pressure gauge
e. volume of gas	thermometer

28. This reaction WILL NOT be speeded up by.

a. using more vinegar
b. using a bigger piece of metal
c. placing the test tube in a bath of warm water
d. grinding the metal into a powder
e. using two pieces of metal

29. A state of equilibrium exists between the liquid and gaseous phases:
liquid vapour. What will happen if the system is cooled off?

a. more vapour will be formed
b. more liquid will be formed
c. the rate of the forward reaction will increase
d. the rate of the reverse reaction will decrease
e. the rates of the forward and reverse reactions will decrease

30. Two identical point charges of $1,6 \times 10^{-10}$C, is placed 0,01m apart. What is the magnitude of the force between them? ($k = 9 \times 10^{9}$ Nm^2/C^2)

a. 144N
b. $1,5 \times 10^{-3}$N
c. $2,3 \times 10^{-6}$N
d. $2,3 \times 10^{-8}$N
e. $2,56 \times 10^{-18}$N

31. 1 ohm is

a. 1J / 1A
b. 1V / 1A
c. 1J.1C
d. 1A.1s
e. 1J / 1s

32. The escalator in the sketch is used to move 20 passengers a minute from the first floor of a building to the second, 5m above. If the average mass of the passengers is 60kg, the power required to move them is approximately

a. 100W
b. 200W
c. 1 000W
d. 2 000W
e. 60 000W

33. In which of the following reactions has reduction of the underlined particle taken place?

a. $\underline{Cu^{2+}(aq)} + 2I^{-}(aq) \quad CuI(s) + 1/2\ I_2(aq)$
b. $\underline{5Fe^{2+}(aq)} + MnO^{4+}(aq) + 8H^{+}(aq) \quad 5Fe^{3+}(aq) + Mn^{+}(aq) + 4H2O(l)$
c. $\underline{Pb^{2+}(aq)} + 2Cl^{-}(aq) \quad PbCl_2(s)$
d. $\underline{CaCO_3(s)} \quad CaO(s) + CO_2(g)$
e. $\underline{Zn(s)} + 2HCl \quad Zn^{2+}(aq) + 2Cl^{-} + 2H^{+}$

34. The difference between a strong and a weak acid is that the strong acid loses its protons more readily. When both dissociate, the equilibrium is marked by the presence of

	Strong acid	weak acid
a.	more ions	less ions
b.	less ions	more ions
c.	the same amount of ions for both	
d.	less H^{+}	more H^{+}
e.	more ions	more ions

35. Two friends Al (40kg) and Jo (25kg) slide down a dune on identical boards. If they follow the same path who would reach the bottom first and why.

a. Al because he is heavier
b. Jo because he is lighter
c. Al because if you heavier you slide faster
d. Jo because acceleration is inversely proportional to mass
e. b and d

36. Work out the speed of these animals. (speed = distance time) and present your answer in such a way that anyone could easily see which animal is the fastest.

1. a pigeon flies 200m in 10 seconds
2. a cat walks 50m in 25 seconds
3. a tadpole swims 10cm in 2 seconds

Your answer is

	pigeon	cat	tadpole
a.	20m/s	2m/s	5cm/s
b.	20m/s	2m/s	0,05m/s
c.	20m/s	2m/s	500m/s
d.	20m/s	2m/s	500cm/s
e.	2000cm/s	200cm/s	500cm/s

37. The class measured their reaction time. The reaction - time chart is used to rate yourself as either excellent / very good / good / fair / poor. How would you change the chart so it would be easier to understand /use?

a. draw the chart with 30cm on top and 0cm at the bottom
b. leave out the ratings quite good and below average
c. leave the chart unchanged
d. leave out the times for quite good and below average
e. do a, b and d

38. The flesh of an avocado pear turns African in air within minutes. The following equipment can be used to find out if vinegar stops this Africanening. Write down the order in which you are going to use the equipment when performing the experiment.

The order is:
a. [knife - avocado pear], [petri - dish - vinegar], [timer]
b. [dish - vinegar], [timer], [knife - avocado pear]
c. [dish - vinegar], [knife - avocado pear], [timer]
d. [knife - avocado pear], [timer], [dish - vinegar]
e. [timer], [knife - avocado pear], [dish - vinegar]

39. Sam performed a titration experiment. The instructions were to fill the burette with the dilute solution of alkali; to pour the acid solution and the litmus in the beaker and then observe any changes. He reported a colour change from blue to red. What do you think did he do wrong?

a. the alkali was too diluted
b. the acid was too diluted
c. he did not an indicator
d. he put the litmus in the alkaline solution
e. he put the alkali in the beaker and the acid and litmus in the burette

40. You add three metals to a bucket of water. You observe the following:

Metal	*Observation*
A	*bubbles fast; metal still there after 30min.*
B	*metal disappears in 2 min.; loads of bubbles*
C	*metal buzzes and goes on fire*

You are about to add a fourth metal to fresh water. This metal is less reactive than the other three. What might you observe?

a. metal moves around on the surface of the water
b. a few bubbles appear in 1 hour
c. metal burns with a yellow flame
d. metal sinks and bubbles appear fast
e. metal buzzes, but does not go on fire

ANNEXURE L SCIENCE COMPETENCY TEST

Formulae and Physical Constants	
$W=Fs$	**$g=10m/s^2$**
$F=kQ_1Q_2/r^2$	**$c=m/MV$**

1. Which quantity and its unit are grouped correctly

	Quantity	SI - unit
a.	displacement	m^3
b.	time	s
c.	impulse	Pa
d.	distance	cm
e.	gravity	m / s^2

2. When working in a laboratory one should take care to always

a. use only the required amounts of chemicals for an experiment
b. never to pour reagents back into the bottles
c. wipe up spills immediately
d. taste the chemical if you are not sure what it is
e. only a, b and c is true

3. You are asked to connect two 1 ohm bulbs in series with an ammeter and a 1,5 volt battery. If you follow the instructions your circuit should look like:

4. A scalar is a quantity with

a. direction only
b. magnitude only
c. velocity
d. magnitude and direction
e. velocity and direction

5. A body of mass 20kg is lifted 15m high from the floor. The work done (in Joules) is

a. 300
b. 450
c. 2 250
d. 3 000
e. 6 00

6. What is the definition of reduction?

a. a loss of protons
b. a gain of protons
c. a loss of electrons
d. a gain of electrons
e. a gain of neutrons

7. In the formula W = Fs, the unit of s can be

a. m or km
b. m or cm
c. cm only
d. m only
e. mm or m

8. A conductor has a resistance of 1 when a …….i…….. flows through the conductor when the …….ii……. is maintained between its ends.

	i	ii
a.	charge of 1C	electrical energy of 1J
b.	power of 1J/s	current of 1A
c.	charge of 1s	electrical energy of 1J
d.	current of 1A	potential difference of 1V
e.	power of 1J/s	current of 1A

9. During standardization of a dilute solution of acid with a dilute solution of base the pH at the time of colour change is

a. 1
b. 2
c. 7
d. 13
e. 14

10. Give the concentration of 14,5g/dm^3 NaCl in mol/dm^3. Given that: M(NaCl) = 58g/mol.

a. 0.25
b. 0.5

c. 1
d. 14.5
e. 58

11. Which compound will you study in Organic Chemistry?

a. CH_4
b. H_2S
c. NH_3
d. HCl
e. $CuCO_3$

12. The gas NO_2 is in equilibrium at room temperature with

a. NO
b. N_2O
c. NO_4
d. N_2O_4
e. N_4O_2

13. The bar graph shows in which habitat wood lice prefer to live

Wood lice prefer to live in …

a. wet stones
b. dry leaves
c. dry stones
d. wet sand
e. wet surroundings

14. The table shows how a piece of zinc disappears when reacted with hydrochloric acid.

Time in min.	0	2	4	6	8	10	12
Mass of zinc	5	4	3,5	2,9	2,6	2,5	2,5

A graph of the results will look like:

15. Which trolley will accelerate the fastest?

16. When investigating the relationship between acceleration and force (mass is kept constant) the trolley is placed on an incline

a. To make it run fast
b. To overcome friction
c. Because it accelerates better that way
d. Because it is better to apply a force in this position
e. So that everybody can see the trolley

17. In an electrochemical cell experiment the salt bridge is used to

a. connect the two half cells
b. maintain electrical neutrality in the half cells

c. transfer the positive ions
d. transfer of negative ions
e. all of the above

18. If QV/s = mg, then s is equal to

a. mgQV
b. mg/QV
c. mgV/Q
d. QV/mg
e. mgQ/V

19. A state of equilibrium exists between the liquid and gaseous phases :
liquid vapour . What will happen if the system is cooled off?

a. more vapour will be formed
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25. The apparatus is used to investigate Boyle's Law. What are the labels?

	1	2
a.	pressure gauge	volume of gas
b.	thermometer	volume of gas
c.	thermometer	pressure gauge
d.	volume of gas	pressure gauge
e.	volume of gas	thermometer

26. Consider the reaction below and choose the correct option.
$Cl_2 + I^-$ $Cl^- + I_2$

	substance oxidised	substance reduced	oxidising agent	reducing agent
a.	Cl	I	Cl	I
b.	I	Cl	I	Cl
c.	I	Cl	Cl	I
d.	Cl	I	I	Cl
e.	Cl	Cl	I	I

27. A standard solution always has a

a. concentration of 1 mol/dm^3
b. concentration of 1 g/dm^3
c. concentration of 1 mol/dm^3 at 25^{0}C
d. concentration of 1 g/dm^3 at 25^{0}C
e. precisely known concentration

28. Two forces T_1 and T_2 are working on the same body. (see sketch). You want to determine the resultant of the two forces graphically. The direction of the resultant is

a. north
b. east
c. south
d. west
e. northeast

29. Tyron is trying to find out how much solid is dissolved in a sample of river water. The pictures show the stages in the method of his experiment, but they have been jumbled up. The correct order of the stages is

a. A-B-C-D-E-F
b. C-E-B-A-F-D
c. C-E-D-F-A-B
d. C-E-B-D-A-F
e. C-D-E-F-A-B

30. When performing the experiment depicted in the sketch, which rule are you investigating?

1. sine rule
2. paralellogram rule
3. triangle rule
4. vector rule

The correct rule (s) is /are:

a. 1, 2
b. 3, 4
c. 1, 4
d. 2, 3
e. 2, 4