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LEARNING POTENTIAL AND ACADEMIC LITERACY TESTS AS PREDICTORS OF ACADEMIC PERFORMANCE FOR ENGINEERING STUDENTS

By

Monica Logie

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Concept Declaration

I, Monica Logie, declare that **"Learning potential and academic literacy tests as predictors of academic performance for engineering students"** is my own work. All the resources that I have used for this study are cited and referred to in the reference list.

Ms Monica Logie   Date

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Abstract

The aim of this study was to evaluate a battery of tests to be used as part of the process of selecting bursary students for engineering at tertiary institutions. Due to the problems in the schooling system it is not conclusive that all students who have obtained their senior certificates are prepared and able to meet the demands and challenges of tertiary education. The purpose of this study was to determine the criterion related validity of a mathematic proficiency test, Learning Potential Computerised Adaptive Test (LPCAT) and English Literacy Skills Assessment (ELSA) as predictors of academic performance. A quantitative approach was used for the purpose of this study. More specifically the Ex post facto analyses/design is used in this study. The relationships between the dependent and independent variables were determined. Correlation analyses, Kruskal-Wallis test and regression analysis were used for the purpose of this study. The results indicated that the Mathematical proficiency test was the best predictor of academic success, followed by LPCAT and ELSA. The results of this study indicates that the use of academic literacy and learning potential contribute in selecting the best students. Companies and Universities have long been looking for a predictor or predictors of success for students as they enter tertiary studies. This information has the potential to save companies and universities millions of Rands annually by helping them make better investment decisions.

Chapter One: Introduction

1.1 Introduction

The core of any intangible assets of a company is the extent and quality of its human capital (Le Roux, 2006). Development of human capital serves not only the economic interest of the company itself, but also the broader requirements of the society within which the company operates.

From 2005 there has been a huge increase in projects, especially by government regarding infrastructure e.g. road improvement projects and reconstruction and development programme's. The FIFA Word Cup taking place in South Africa is also placing a big demand on the industry, due to improvements that need to be made to current infrastructure (Inngs, 2007). Due to this, the market demand for skilled workers in the field of science, e.g. engineers, is set to increase substantially.

This is the case in South Africa as well as other countries, with a huge global demand for infrastructural services, creating a huge demand for engineers. With the current skills shortage in South Africa, the number of graduates needs to be increased to make up the shortage (The National Skills Development Handbook, 2007).

The selection of students is a critical issue currently facing South Africa. Changes in the South African educational system have intensified the need for proven fair selection (Zaaiman, van der Flier & Thijs, 2000). Companies have long been looking for a predictor or predictors of success for students as they enter university for tertiary studies. The need for accurate predictors arises from bad investments made by companies when awarding bursaries to students unable to complete their studies (Le Roux, 2006). Selection decisions are often based upon a combination of qualitative and quantitative evidence (Brashears & Baker, 2001). Qualitative evidence can include leadership qualities and achievements at school as well as the structured interview during bursary selection. Quantitative evidence is typically school or university results.

Up to now quantitative evidence was used in making bursary selections. Miller (1992) refers to this system as using the past to predict the future: in the past this method appeared to have been a good and consistent indicator of future academic success. Matriculation results were a surprisingly excellent indicator of subsequent academic success for first year intake of students (Badenhorst, Foster & Lea, 1990; Potter & van der Merwe, 1993a; Jawitz, 1995).

The mentioned traditional practice, to utilize matriculation results as the key selector for entrance to tertiary study purposes, is still applicable. This practice is based on the assumption that school academic performance is a useful and reliable predictor of performance on tertiary level (Ngidi, 2007). However, the difference in educational opportunities at school level complicates the development of fair and effective selection mechanisms (Zaaiman et al., 2000).

The need for this study arises from the discrepancies in our education system. Students in urban, peri-urban and rural areas are comparingly not exposed to the same type and standard of education (Department of Education). Skuy, Zolezzi, Mentis, Fridjohn and Cockfort (1996) indicated that matriculation cannot be taken as a true reflection of the academic potential of students and the exclusive use of school marks might lead to an unjustifiable exclusion of students.

To equip the company with the fairest possible process when awarding bursaries, a different predictor or predictors need to be identified.

1.2 Problem statement

Human resources are an important factor of production and have a direct impact on the competitiveness of firms (Kleynhans, 2006). The development of human capital within a large petrochemical company is a key driver for competing successfully in a modern global economy. Human capital is those elements in humans that enhance the quality of labour, such as skills, knowledge and wisdom (Kleynhans, 2006). As a large petrochemical company continues to grow in stature as a major regional player in Southern Africa and, increasingly, as an international competitor in select areas of fuel and chemical production and marketing, the attraction and development of talent, especially in the field of science, are a key factor to the continued success (le Roux, 2006).The enhancement in the quality of the human resources entering the company, can lead to lower costs (Kleynhans, 2006). Selecting the best candidates is thus key in achieving this objective.

High school results have been used in the past and very often been found to be a good indicator of subsequent academic and work performance although care should be taken when these marks are used as the primary selection information. According to Nunns and Ortlepp (1994), the use of school results of South African students who are not disadvantaged is justifiable. But the result of local research on relatively disadvantaged students is less convincing (Murphy, 2006). As Shochet (1994) argues, results obtained in a disadvantaged social and educational system cannot accurately reflect academic potential. Entrance to South African tertiary education was gained through the possession of a matriculation school-leaving certificate. A score was awarded to a specific subject grade. If a sufficient score was obtained, and, in some disciplines, specific subjects passed, requirements were met, entrance to the tertiary institution was allowed (Stephen, 2007).

The long-established practice of using matriculation results as the prime basis for university entrance is still leading. This practice is based on the assumption that school academic performance is a useful and reliable predictor of performance in higher education. Badenhorst, Foster and Lea (1990) indicate that predictability of the matriculation results appears to vary from the one tertiary institution to another; this is inline with claims that school achievement has very limited value as a predictor of student success in tertiary education (Ngidi, 2007). For that reason, the majority of tertiary institutions in South Africa have launched some form of admission or selection tests in response to the concern about the academic literacy levels of first year students (Weideman, 2003).

Additional assessment is necessary to conduct the fairest possible selection process. Testing and assessments are synonymous with determining advancement in education. No matter the purpose of the test, the aim of testing is to determine the test taker’s ability to perform at a specific level in a specific discipline (Scholtz & Allen-ile, 2007). The first consideration when assessment measures are selected is the fact that it should differentiate between the academic needs of students who currently show academic excellence and the needs of those who show less significant accomplishments, but have the potential for developing academic excellence (Lohman, 2005). For that reason the Learning Potential Computerised Adaptive Test was included in this study.

Using only a behavioural based selection interview will not suffice. Over the past years meta-analyses have led to more optimistic conclusions but also show that there is significant room for improvement when using interviews for selection purposes (McDaniel, Whetzel, Schmidt & Maurer, 1994). While interviews can be a useful tool to gain information, it does however have a number of weaknesses. The reason for this lies in the fact that interviews are an unstandardised assessment procedure (Dipboye, Gaugler, Hayes & Parker, 2001). Even if the same questions are asked, the interpretation will differ. It is therefore important that more than one person interview a specific student.

Test results can be represented numerically, making it easy to compare applicants with each other. The Learning potential and academic literacy tests provide a range of information which is not easily and reliably assessed in other ways. This information fill important gaps that have not been assessed by application forms or selection interviews.

The question: Are the key predictors (literacy tests and a learning potential test) as identified by the company adequate predictors for academic success?

1.3 Purpose of the study

The purpose of this study is to determine the criterion related validity of academic literacy tests and a test for learning potential as predictors of academic performance for students in the field of engineering.

1.4 Significance of the study

The significance for this study is twofold:

1. Literature – The literature and research finding of this study will enable companies to have an improved selection drive in the future.
2. Methodology –This study also has a positive cost implication for companies making use of these research finding. Time, money and effort will be channelled in the right direction without wasting resources on ineffective tests and unsuccessful students.

1.5 Research Objective

The general objective of this study is to identify and explore the predictive value of the English Literacy Skills Assessment (ELSA); Mathematical proficiency test and the Learning Potential Computerised Adaptive Test (LPCAT) towards predicting the academic performance of students studying engineering at tertiary level.

The research problem at hand is to determine the answer to the following questions:

1. Do the academic literacy tests and learning potential test results correlate at a statistically and practically significant level with the academic performance at tertiary level?
2. Do the academic literacy tests and learning potential test results discriminate effectively at a statistically and practically significant level between the various levels of academic performance?

1.6 A brief overview of each of the main chapters

Chapter 2:

This chapter will give an in-depth overview of the history of the education problems.

Chapter 3:

This chapter will give an in-depth overview of the history of possible predictors for academic success and the history of psychometrics.

Chapter 4:

The research design, data collection and analysis techniques are explained in this chapter. The measuring instruments used in this study are discussed in terms of history and the development thereof as well as the purpose, scale, administration, reliability and validity of the different instruments.

Chapter 5:

The article will include a short literature discussion based on the content of Chapter 2. The statistical analysis and the results of the statistical procedures will be explained and discussed. The article will conclude with recommendations for further studies.

1. 7. Summary

In this chapter the background of the study was discussed to give an overview and indication of the origin of the need for this study. The proposed research question is also included, and serves as an introduction to the chapters that follow.

Chapter Two: The Educational Landscape

2.1 Introduction

According to information in the National skills development handbook (2007/8) published by the Department of Labour, many skilled South Africans leave the country each year for more prosperous working environments and better opportunities. Van Reenen quoted Dr. Raymond Ngcobo (2008), chief director of strategic competitiveness at the Department of Trade and Industry, that research reveals a possible shortage of 1.5 million to 2 million skilled workers by 2017.

The shortage of skills in our country is even more disturbing in the light of the growing unemployment figures for the people who have completed a tertiary education. This indicates the need to pour money into the right kind of skills to solve the skills shortage. South Africa's need for skills training is reflected in the fact that it is rated close to the bottom of total public expenditure on education as a percentage of gross domestic products (Garelli, 2007).

In a country with 11 official languages, many educational problems, and huge disparities in educational background of individuals, the development of psychological assessment tools will never be a simple matter.(Claassen, 1997; De Beer, 2000a; Foxcroft, 1997; Huysamen, 2002). The present situation affords large petrochemical companies the unique challenge in finding assessment tests for selection purposes that are justifiable, yet practical and useful in the challenges of finding suitable bursary candidates.

A major challenge emerged for the government of national unity in 1994 to get education policies into place that would help undo the legacy of apartheid, and that would result in the establishment of a higher education system that would address the imperatives of transformative conditions such as equal access, development, accountability and quality (Waghid, 2002)

At present, there are still large differences between the cultural groups in South Africa in terms of socio-economic and educational opportunities, as well as general living conditions, with the African group in particular being the poorest off in all respects (Central Statistical Service of South Africa, 1996). People from previously disadvantaged backgrounds often have not had the opportunities to develop their cognitive potential fully and that is the reason for many of them tending to score poorly on standard psychometric instruments (Van Heerden, 1995). Often these poor scores don't necessarily reflect on a lack of potential, but rather on a lack of educational opportunities (Van Heerden, 1995).

A survey by Markdata, the Education Foundation Trust and the Council for Scientific and Industrial Research, found that in South Africa there was a shortage of 45 000 classrooms, over 23 000 schools did not have computers, and 10 000 schools were without electricity (Ngidi, 2002).

2.2 International background to educational challenges

Africa in general is experiencing an educational crisis of exceptional magnitude in higher education (Attech, 1996). Having been hailed in the 1960s as agents of transformation, social mobilization, and economic growth, most African universities are now plummeting under the pressures of deteriorating financial resources. Attech (1996) indicated that from all indications, Africa is behind other developing countries in terms of public expenditures, particularly on education, availability of educational facilities, equal access to education, adequate pools of qualified teachers, and sufficient numbers of professionals and skilled workers.

Furthermore education is in a deep crisis in sub-Saharan Africa. A review of applicable data shows that most of sub-Saharan African countries are now facing deteriorating public expenses on higher education, deteriorating teaching circumstances, crumbling educational facilities and infrastructures, continuous student unrest, wearing away of universities' autonomy, a shortage of skilled and trained educators, a lack of academic freedom, and an increasing rate of unemployment among university graduates (Atteh, 1996).

Given the degree of world-wide moral, economic and social problems, there is increasingly more emphasis and pressure on universities to overcome the gap between higher education and society and to become dynamic associates with parents, teachers, principals, community advocates, business leaders, community agencies, and general citizenry. (Braskamp and Wergin, 1998).

Poor academic performance under minority groups is a worldwide problem. Explanations for differences in academic performance among America's minority students have also been studied (Schneider & Lee, 1990). Although various studies have been conducted to scrutinize academic failure, only a limited number of findings have identified those factors that seem to contribute to the academic success of particular minority groups (Ogbu, 1987). Some of the first explanations for the low academic performance of poor or minority students were based on genetics. Jensen (1969) argued that variations in student achievement were the consequence of inherited differences in cognitive abilities. According to Jensen, Chinese and Japanese I.Q. test scores result from inherited conceptual and problem-solving skills, which improve one's ability to grasp relationships and engage in symbolic thinking (Jensen & Inouye, 1980). Blacks, he challenged, do not perform as well as Asians at school because they inherited fewer of these types of cognitive skills which are emphasized in traditional methods of classroom instruction.

The Netherlands face a serious shortage of students enrolling for scientific and technical careers at tertiary level (Axis, 2003). Science is unpopular with students, especially with female students (van Langen, 2005). The rate of young people enrolling for science and engineering is lower in the Netherlands than in the neighbouring countries (OECD, 2005). It is commonly said that more science and engineering students are needed, given the challenges facing the Dutch economy (Van Bragt, Bakx, Van der Sanden & Croon, 2007). The implementation of a variety of initiatives by the government has resulted in a steady increase in students who enrol to study science at tertiary level, but the number is still not adequate (Axis, 2003; HBO-raad, 2006). Similar problems occur in Germany (Taconis & Kessels, 2009)

2.3 National background to educational challenges

The demand in the labour force for students graduating in the field of science, engineering and technology is reinforced by the fact that it is the key objective of the South African National Plan for Higher Education to shift the balance of enrolment to tertiary studies from the humanities to business and commerce and most of all to science, engineering and technology (Department of Education, 2001).

Despite late-apartheid reforms, education remains a critical element of post-apartheid restructuring nationally. In 1994, President Nelson Mandela, leader of the African National Congress (ANC), the new ruling party, inherited a racially divided and highly discriminatory education system. The normal white student, in 1994, benefited from education costs that were nearly four times more for an African student (Lemon, 2004)

Elements of a market-driven system were introduced in traditionally white schools in early 1990s, ceding control to governing bodies of “model C” schools to which the physical assets were transferred, leading to the right of entry for a small numbers of black students but at costs affordable only by middle-class parents (Lemon, 2004).

It is not the intention of this study to critique the national education system, rather to give perspective of where this study is coming from in terms of education in South Africa.

Grade 12 figures have not only declined in South Africa over the past 5 to 8 years, but the number of learners with mathematics and science on higher grade is very low (Horak & Ficke, 2004). Those that pass with acceptable symbols for admission to studies in engineering at universities is even less. Studies in engineering at university level require Grade 12 with exemption, with mathematics or pure mathematics and science on higher grade, preferably with a C symbol or higher (Horak & Fricke, 2004).

Enrolment for standard grade mathematics has increased significantly in recent years, but the pass rate in 2003 was only 44.7 per cent. Conversely, the pass rate in higher grade mathematics has improved – but enrolment has plummeted, from 65 616 in 1995 to 35 959 in 2003 (Clynick & Leer, 2004). The same pattern is followed in physical science.

In 2003 the system produced only 2 735 more students passing HG mathematics than it did in 1991. The same is true for HG science - in 2003 only 2 958 students more passed than in 1991 (Clynick & Leer, 2004). This poses an increasingly difficult challenge to find suitable candidates to award bursaries to in the engineering disciplines.

The mathematics results for the group of grade 12 students matriculating in 2008 were exceptionally high and many more students qualified for university entrance; 63 000 (2009) compared to 25 000 (2008). Although there were significantly more student qualifying for university entrance, the first semester mathematics related results for 2009 first year students at tertiary institutions were disturbing (Huntley, 2009).

Course	June 2008		June 2009		National Senior Certificate level
	Student no	Pass rate	Student no	Pass rate	Min
Mathematics Statistics 1	170 (capped)*	51%	170(capped)*	29%	7(A)
Mathematics 1 Major	419	50%	652	31%	6(B)
Mathematics 1 Engineering	666	71%	1239	35%	5(C)
Ancillary Mathematics & Statistics 1	369	75%	453	60%	4(D)

* The sample was restricted to 170

According to Hyntley (2009) the majority of the 2009 students at South African universities have the following characteristics:

1. They are the first group to have been subjected to the Outcome Based Education (OBE) approach for their entire school career.
2. They are the first group for whom some type of mathematics was compulsory up to Grade 12 level in the form of Mathematics or mathematical literacy.
3. The mathematics marks for this group of grade 12 students were exceptionally high and many more students qualified for entrance into a tertiary institution.

OBE does not have a single historical inheritance. There are indications that it traces back from behavioural psychology associated with B.F. Skinner; other indications are to mastery learning as championed by Benjamin Bloom. Then again some indicators associate OBE with the curriculum objectives of Ralph Tyler. Finally claims are made that OBE derives from the competency education models associated with vocational education in the UK (Mohamed, 1996). In South Africa, the most immediate origins of OBE are in the competency debate followed in Australia and New Zealand (Christie, 1995). This activated training and development discussions in the Congress of South African Trade Unions (COSATU), which eventually appeared in documents of the National Training Board and subsequently crystallised in the National Qualification Framework (NQF) (Jansen, 1998).

For all learning theories or approaches there are benefits and shortcomings. Huntley (2009) made the following observations with regards to the cohort of the 2009 students in terms of their numerical ability and skills:

- Students lack spatial reasoning
- Students cannot read and interpret word problems
- Students believe that there are algorithms and rules that will solve every problem.
- Students lack the ability to see and prove complex connections
- Students have an unrealistic expectation of their mathematical abilities.

Anecdotal evidence suggests that the cohort 2009 students exposed to OBE from their first day at school, take to reading tasks more easily and more readily, they have more self-confidence and are resourceful and seem to engage more competently in group work tasks and self-study. This indicates that students applying for tertiary education have changed in recent years and that current assessment practices need to be revised.

2.4 Summary

In order to determine the criterion related validity of academic literacy tests and a test for learning potential as predictors of performance in engineering science at tertiary level, it is necessary to establish the current trends and background in terms of academic performance. This will assist in identifying the shortcomings in the education system and where additional tests need to be performed.

It is evident that the education landscape has it inequalities. For that reason, using results obtained in an education system that is discriminatory, could lead to the perception that such selection procedures are unfair (Van Eeden, De Beer & Coetzee, 2001). It is evident from the abovementioned results that Grade 12 mathematics results alone can not be used as the only indicator for tertiary entrance. Chapter 3 will deal with the literature on the different predictors for this study.

Chapter 3: Predictors, academic success and criterion validity.

3.1 Introduction

Research by Mitchell, Haupt and Stephenson (1993) showed that "matriculation skills account for 20% of first year performance" among medical students. This implies that other factors besides matriculation results should be considered. In this chapter the aim is to investigate and give an overview of what possible predictors might be used to predict academic success.

3.2. Current practice at tertiary institutions in terms of admission tests.

A variety of reasons may be given for conducting proficiency tests in academic literacy at tertiary education institutions. According to Weideman (2003) most tertiary intuitions in South Africa have introduced some form of analytical selection tests in reaction to the concern about the academic literacy levels of first year students. A lack of ability in academic literacy could put students at risk of not completing their courses in the minimum time, which has a cost implication for the institution as well as the students or the person supporting the student financially (Scholtz & Allen-ile, 2007).

According to Griesel (2006) the following assumptions underline the need for benchmarking entry level ability to tertiary education study.

1. School leaving results might sometimes give an inaccurate reflection of a student's intellectual ability.
2. Variability in student diversity ranges from linguistic and cultural diversity to the rural/urban, advantaged/disadvantaged divide that undeniably impacts on learner performance.

Given the unpredictable profile of students, it is not conclusive that all students who have obtained their senior certificates are prepared and able to meet the demands and challenges of tertiary education. In that light, an academic literacy test should be deemed essential in providing insight into the intellectual profile and academic readiness of students (Scholtz & Allen-ile, 2007). Suitable and timely interventions based on the results and analyses of selection tests could implicate far-reaching positive and financial implications for the individual by becoming economically productive, for the institutions by improving through-put rates and subsidies and for the country as a whole by contributing to the economic advancement in South Africa.

Proficiency tests are used at various institutions of higher learning in South Africa. The Standardised Assessment Test for Access and Placement (SATAP) is used by the Cape Peninsula University of Technology (CPUT). The University of Cape Town has established the Alternative Admission Research Project (AARP), while the University of Pretoria has the Test of Academic Literacy Levels (Van Dyk & Weideman, 2004). A grouping of one or more of these tests is used by different tertiary institutions in South Africa.

Placement and selection tests are not unique to the tertiary education in South Africa. The United States of America witnessed an exceptional number of students applying for limited places at colleges and universities. About 2.6 million students wrote one or more standardised assessment test to qualify for entrance, out of an annual high school graduating class of 3 million nationally (Greene & Greene, 2004). As in the case in South Africa, the US institutions have varying entrance examination and admission policies (Scholtz & Allen-ile, 2007).

An indication of the urgency and importance of determining the academic preparedness of entry-level students is that the former South African Universities Vice-Chancellors Association (SAUVCA) and the Committee of Technikon Principals (CTP) approved the proposal of the National Benchmark test (NBT). Benchmarks are an indication of the expected level of academic literacy that students should attain and that all learners should reach with certain grade levels and tertiary entry levels. According to Foxcroft (2006), it is a point of reference for evaluating and monitoring the adequacy of achievements and educational development of learners.

Proficiency tests for placement and selection have become the established norm at most tertiary institutions in South Africa.

3.3 The concept and context of academic proficiency tests

For numerous reasons one is often required to compare different individuals with one another. The measurement instruments used to gather this kind of information are known as proficiency tests (Van Eeden et al., 2001). Proficiency tests were developed in response to the practical need to select and classify people in different settings. (Anastasi & Urbina, 1997).

The main purpose of using proficiency tests for selection purposes in tertiary education is to identify possible students who will succeed at tertiary level (Zaaiman, van der Flier & Thijs, 2000). According to Van Eeden (2001) these kinds of assessments only provide an indication of what was measured and is not a perfectly accurate result as with natural science. The reason for that:

- One is measuring in an indirect manner
- Human characteristics may change over time or due to other influences.

Of the selected students, some might pass and other fail (true and false positives) and some of the rejected students would have been able to pass (false negative).The intent of using proficiency tests for selection purposes is to minimise the false positives and false negatives in the selection or rejection of students (Zaaiman, 2000).

Consistency of a test is developed when there are uniform procedures for its administration and scoring, as well as normative data on which to base the interpretation of scores. Tests are primarily evaluated in terms of validity and reliability. Reliability is the consistency of their scores and validity the extent of what we know they measure (Anastasi & Urbina, 1997).

Owen (1991, 1992) indicated that significant differences in the mean test scores of whites and blacks are found when assessments are administered in English to black students whose first language is an African language. According to Van den Berg (1996) language proficiency is the most important moderator of test performance as it reflects knowledge with concepts and access to the language medium through which knowledge has to be gained.

According to Shochet (1994), tests of cognitive abilities that reflect the individual's current level of functioning, rely to a large extent on previous learning experience. So groups from disadvantaged educational backgrounds typically do not perform well on these assessments. Taylor (1994) re-emphasises the importance of identifying those students who have potential for development, even though their abilities are currently limited by past disadvantages.

Another significant influence in the test performance of individuals, is the language, predominantly when the test is not administered in the individual's home language (Schoeman, De Beer & Visser, 2008). Language proficiency is also of significant importance when individuals receive their training in a different language (Abrahams & Mauer, 1999; Foxcroft, 1997). In multilingual South Africa, fair testing practices necessitate the assessment of individuals' language proficiency in the language in which the assessment is to be done. English is used as the business language and is also the most common language of communication in South African between different population groups. Nevertheless, when English is not the home language of individuals, English language ability influences their learning, training and performance (Van Eeden, 2001). Most black people currently prefer to receive their education in English (Rossouw, 1999). This acquirement of second language literacy is influenced by ability in the first language, the incentive to learn a second language, as well as cultural determinants. To be academically literate, second language English speakers need to master English for academic purposes over and above English as a second language (Gruenewaldt, 1999). Language proficiency is a determining factor that may influence an individual performance on assessment; this should be recognised during assessment.

The first step in the process of choosing a selection battery of proficiency tests, is to know what has to be assessed. Tests need to be designed using test specifications based on a task specification, which is usually based on the curriculum in the educational context (Zaaiman, 2000). The next section of this chapter investigates the importance of Language, Mathematical skills and learning potential in the prediction of academic success. Previous research combining these elements in a selection battery was done by Scholtz & Allen-ile (2007). The results of their study indicate that Grade 12 results aren't adequate in selecting potential students and that a need for academic proficiency tests in the current educational climate cannot be overemphasised. Reasonable probability of academic performance was reported by using their assessment battery.

3.3.1 Language and Mathematics

The ongoing problem of poor academic performance of many students at primary, secondary and tertiary level is disconcerting, especially in science and mathematics. The theoretical complexity and problem solving environment of these disciplines make a wide range of demands on the reasoning, interpretive and strategic skills of students, especially when practiced in a language that is not the student's first language. In South Africa the students have achieved the questionable distinction of being at the bottom of the list in the Third International Mathematics and Science Study 1999 (TIMSS). Even with the controversy surrounding these tests, the fact remains that in comparison to the rest of Africa, South African students performed extremely poorly (Bohlmann & Pretorius, 2002).

As long ago as 1987 Dale and Cuevas (1987) pointed out that the proficiency in the language in which mathematics is taught, especially reading proficiency, was a prerequisite for mathematics achievement. During 2000, an interdisciplinary reading skills project was launched by the Departments of Mathematics and Linguistics at Unisa. The aim of the study was to assess the reading skills of mathematics students, and to explore the relationship between reading skills and performance in mathematics, and to identify the problem areas. The sample for this research was 402 students. The findings showed a robust relationship between reading ability and mathematics performance (Bohlamann & Pretorius, 2002).

3.3.2 Language proficiency and academic success

The role of language in academic success was discussed by numerous linguists over the years (John, 1970; Ervin-Tripp, 1970; Freeman, 1998); as well as South African academics who have worked on the same issue (Angelil-Carter, 1998). They all agree, in general, that it is difficult to be specific about the contribution of the language factor to learning, emphasising that there are many other factors involved in the process.

According to Webb (2002) informal observation implies that academic staff often has an inadequate appreciation of the role of language in the development and the assessment of students' academic performance. They give the impression that language is only important in terms of students being able to spell and using the correct punctuation. The lack of appreciation of the role of language in academic training was also confirmed in the 1996 report of the National Commission of Higher Education in South Africa.

Webb (2002) indicated that language is fundamental to educational development in at least two ways:

1. It is a fundamental instrument in students' cognitive, affective and social development; and
2. It is an essential object of teaching, in the sense that becoming academically trained implies learning to use the language of the specific science appropriately in professional contexts, as well as learning to use language for general purposes.

Educational development is concerned with the gaining of knowledge, with integrating new knowledge into the existing bases of knowledge, with gaining the rules that govern the storage and retrieval of information, with grasping scientific and scholarly concepts and learning the terms for these concepts, with understanding the processes and principles of a particular field of learning, and with using these concepts and principles to solve problems. Academic training also means being able to gather information/data, accept its analysis and interpretation, and manage it in problem-solving. It means to learn to discover patterns and rules, to reason, to identify a scientific fact, to test a suggestion, to identify, construct and evaluate scientific arguments, to find plausible and coherent explanations for phenomena and to evaluate points of view and ideas critically (Hernandez, 1993).

These high-level cognitive, affective and social skills do not generally develop in a "spontaneous" way. As Hernandez (1993) points out, cognitive and meta-cognitive skills are acquired "through social interaction (with experts in the field) where comprehensible communication occurs and active awareness of these comprehension problems and problem-solving strategies is demonstrated." This applies to social and affective skills. The development of these skills is reliant on language.

The role of language is even more important taking into account the background of multilingualism and cultural heterogeneity as is the case in South African Universities. South African universities, in particular the historically white institutions, have become linguistically and culturally considerably diverse. This implies that many of their students come from social worlds which differ significantly from the world of these institutions, especially in the sense of having been less exposed to the values, norms, behaviour patterns, and so forth, presupposed by the institution. These differences could imply situations of conflict, resulting in experiences of unfriendliness and insecurity. In such situations, language plays an important mediatory role (Webb, 2000)

Consideration should also be give to second-language students and how this relates to the effect of the social meaning of first languages. Ervin-Tripp (1970) points out that users of the minority languages are disadvantaged to the degree in which they experience a sense of inferiority, have low expectations of their own achievements, have a negative perception of the power of their own social group, receive or do not receive respect for their first languages, and by the degree to which they are expected to compete with native speakers.

In general, English is held in excessively high esteem in South Africa, while the Bantu languages are generally socially stigmatised (Webb, 2000).

Given that language is an elementary factor to academic development, the question is what the effect will be on academic success when students need to use a second language (Webb, 2002).

If further consideration is given to the fundamental role of language, linguistic behaviour is critical in professional occupations, and the proficiency in language is non-negotiable for competitiveness in the national and international marketplace. It is thus self-evident that the issue of language in academic development and assessment across all disciplines is serious (Lemmer, 1991).

The above mentioned is gained from the conclusions by Lemmer (1991) about the consequences of inadequate proficiency in the language of learning and training at tertiary level. Lemmer (1991) points out those speaking minority languages usually suffer serious effects such as poor academic achievements as well as poor foundation for cognitive development and academic progress.

This point of view of Lemmer is shared by other researchers. The value of language in tertiary education was researched by Zaaiman (2002) on students at the University of the North. Their research findings indicate a significantly high predictive validity for students who were successfully selected based on language proficiency tests. Webb (2002) conducted a similar study at the University of Pretoria researching the importance of language proficiency and the effect of second language at tertiary institutions. The study of Webb (2002) proved that inadequate language proficiency hinders meaningful participation in class and note-taking. The inadequate guidance to students about handling language problems can result in students performing below their potential and might result in failing of courses.

Language proficiency can thus be described as fundamental in academic training, as it can either facilitate academic development, or be a barrier.

3.3.3 Mathematical proficiency

In spite of the fact that mathematics is the foundation of scientific literacy, many South African students do not perform sufficiently in this subject. Adopting an Outcomes Based Education (OBE) approach has not contributed to an improvement of the situation (Maree & Lana, 2007).

Due to its widely accepted predictive validity, passing mathematics in Grade 12 is regarded as an admission requirement for undergraduate studies in the fields of science, engineering and technology. This is not an experience that is unique to South Africa (Furner & Bernan,2003). Mathematics can be described as the first step to careers in science, engineering and technology (Furner, 2003). Admission requirements based on Grade 12 results are a contentious issue due to the historical differences in the education systems at schools (Skuy, 1996; Department of Education, 2003).

The mathematical skills of first year students have gradually become a focus point in mathematics education research, for example research by Ferrini-Mundy and Gaudard (1993); Firth, Frith and Conradie (2006) and Hooper (2006).

The University of Pretoria became aware of the lack of understanding of first year students in terms of fundamental mathematical concepts. In addition to that, the lack of competence in communication skills, especially technical (including mathematical) communication skills were also noted (Du Preeze, Steyn & Owen, 2008). A similar observation was made in the United States where a survey revealed that an increasing number of incoming students needed remedial courses in mathematics and English (Graff & Leiffer, 2005).

A study on a basic mathematical skills test as a predictor of performance at tertiary level for students studying in science and engineering was done by Eiselen, Strauss and Jonck (2007). This study provided support for the use of an assessment, independent of Grade 12 results, for the measurement of basic mathematical skills of students entering into tertiary education. The mathematical skills test showed to be a significant predictor of success, especially in the first semester of tertiary training.

3.4 Non-verbal ability tests

To ensure that training and education are aimed at potentially the most responsive and deserving students, it is necessary that such students have the potential to develop. The measurement of learning potential rather than the measurement of inherent and learned aptitudes is progressively more used in South Africa for the assessment of cognitive functioning (Murphy, 2002). Many cognitive assessments can potentially cause problems, because they measure only current cognitive abilities, and do not measure students' capacity to gain skills, strategies and operations in new situations (Feuerstein, Feuerstein & Gross, 1997; Foxcroft, 1997). This initiated the techniques referred to as culture-fair, such as learning potential assessment (Murphy 2002; Taylor, 1994).

To deal with the shortcomings of traditional intelligence testing, learning potential assessment has been developed as an alternative strategy for the assessment of cognitive functioning (Murphy 2002). Potential is frequently defined as individuals' unrevealed innate capacities, which are probably greater than their manifest level of functioning (Feuerstein, Feuerstein & Gross, 1997). Learning potential assessment measures individuals' present levels of ability as well as their potential for improvement with help (Haywood & Tzuriel, 1992). This definition of learning potential implies that some form of training, which allows for differences in prior learning experiences, must be integrated into the way in which learning potential is measured. This approach to learning potential testing is called dynamic assessment and is based on Vygotsky's concepts of proximal and actual levels of development (Haywood & Tzuriel, 1992; Vygotsky, 1978).

The measurement of learning potential comprises two different approaches: the **enrichment approach** adhered to by Feuerstein, Rand, Jensen, Kaniel and Tzuriel (1987), in which assessment is used to analyse and change the thinking processes of the individual, and the **psychometric approach**, which is there to measure rather than enrich (De Beer, 2006). In the psychometric approach, learning potential tests are standardised to ensure measurement accuracy to allow for comparison between individuals. This assessment can be used for selection purposes. These assessments focus on existing and improved levels of functioning to evaluate the capacity for gaining new skills or knowledge when training is provided (De Beer, 2000a).

Van Eeden (2001) investigated cognitive ability, learning potential, and personality traits as predictors of academic achievement by engineering and other science and technology students. Correlation with the criterion as well as the regression analyses indicated that school achievement was the best cognitive predictor of average first-year performance. Of the psychometric tests, the General Scholastic Aptitude Tests (GSAT) seemed to be a good predictor of first-year performance. The pre-test and post-test of the LPCAT did not seem to predict academic success. However, this test aims to measure modifiability, and it should be used for identifying students who will benefit most from a support programme rather than those who are already performing at a specific level. Lohman (2005) gave similar feedback after his study on non-verbal ability tests. He indicated that nonverbal/figural reasoning abilities should be used as a helpful adjunct, but not as the last resort or only measurement instrument.

3.5 Background of criterion related validity

Usually, validity is viewed as the extent to which a measurement procedure actually measures what it is designed to measure. Such a view is inadequate, for it implies that a procedure has only one validity, which is determined by a single study (Guion, 2002).

Various methods of validation revolve around two issues. Firstly, what is measured and secondly how well it is measured. Validity is thus not a dichotomous variable (i.e. valid or not valid) it is rather a matter of degree (Casio, 2005).

Validity is a unitary concept according to Landy (1986). Although evidence of validity may be gathered in different ways, validity always refers to the degree to which the evidence supports inferences that are made from the scores. Validity is not a single number or a single argument, but a conclusion from all of the available evidence (Guion, 2002). It is the conclusion regarding the specific uses of a test or other measurement procedures, that are validated, not the test itself (Cascio, 2005).

When measures of individual differences are used to predict behaviour, and it can be measured in a practical way, criterion-related evidence of validity is used. This is the approach in this research study. The relationship between the psychometric test scores and the future academic performance on some criterion measure was investigated.

When making use of criteria-related validity, the criterion is a score or a rating that either is available at the time of predictor measurement or will become available at a later time (Cascio, 2005). In this study criterion data will not become available until some time after the predictor scores are obtained. This is thus a predictive study.

A predictive study is oriented toward the future and involves a time interval during which events take place. The term criterion-related draws awareness to the fact that the fundamental concern is with the relationship between predictor and criterion scores, not with predictor scores only. Scores on the predictor function primarily as signs (Wernimont & Campbell, 1968).

A composite criterion score was established for academic results at first year level. All subjects carry equal weight. The data for this study was gathered over a period of 4 years. The first year results for the students were thus not gathered in the same calendar year. Between-rater discrepancies might have an influence on the validity of study (Clauser, Clyman & Swanson, 1999). Between-rater discrepancies appear when different individuals are responsible for ratings. Students are at different Universities, they don't have the same lecturers or the same subjects. They are all studying engineering, but the syllabus might vary from University to University. These are all contaminating factors.

3.5.1 The effect of pre-selection.

Pre-selection occurs when a predictive validity study is undertaken after a group of individuals has been selected, but before criterion data becomes available for them. Estimates of the validity of the procedure will be lowered, since such selected individuals represent a superior selection of all individuals. Since the size of the validity coefficient is a function of two variables, restricting the range of the predictor or of the criterion will serve to lower the size of the validity coefficient (Cascio, 2005)

Careful consideration should be given when interpreting correlation coefficients when it comes from only a small subsection of possible range of scores. Correlation coefficients from studies using a restricted range of cases are often different from studies where the full range of possible scores are sampled (Pallant, 2007). Whenever a sample has a restricted range of scores, the correlation will be reduced. In order to interpret validity coefficients properly, information on the degree of range restriction in either variable should be included (Cascio, 2005).

3.5.2 Criterion measures

It can be argued that a criterion should provide an overall measure of success or the value of each individual to the organisation (Cascio & Aguinis, 2005). The combination of multiple criteria is done subjectively. The fact that a quantitative number is assigned to the criterion makes it possible to objectively analyse the composite criterion.

When a composite criterion is used, the purpose of the study must be taken into account. While a composite criterion might valuably represent and predict an underlying economic dimension, it might not be true from a behavioural studies point of view (Cascio, 2005). A composite criterion makes sense after correlations among criteria have been evaluated. Composite criteria might bring down the predictive validity of the predictors.

According to Cascio (2005) the use of a composite criterion versus multiple criteria depends on the purpose of the study. When the goal of the study is to increase psychological understanding of predictor-criterion relationships, it is best to keep the criteria separate. But when the objective is decision making, the criteria must be calculated into a composite score.

When criterion measures are gathered carelessly with no checks on their worth before use for research purposes, they are often contaminated.

Criterion contamination occurs when the operation or actual criterion includes variance that is unrelated to the ultimate criterion. Contamination itself may be subdivided into two distinct parts: error and bias (Blum & Naylor, 1968). Error by definition is random variation (e.g. due to non standardised procedures in testing, individual fluctuations in feeling) and cannot correlate with anything except by chance alone. Bias, on the other hand, represents systematic criterion contamination and it could correlate with predictor measures.

Because the direction of the deviation from the true criterion score is not specified, biasing factors have the potential to leave the obtained validity coefficient unchanged, increase or decrease it. Biasing factors vary widely in their distortion effect, but primarily this distortion is a function of the degree of their correlation with predictors. The extent of such effects needs to be estimated and their influence controlled either experimentally or statistically (Cascio & Aguinis, 2005).

The following types of bias are likely to have occurred in the duration of this study (Cascio, 2005).

1. *Bias due to group membership*

   Criterion bias can also result due to the fact that individuals belong to certain groups. The assessed students are attending different tertiary institutions. Students have different lecturers evaluating them on subjects. This might have an influence on their average academic results.

2. *Bias in ratings*

   Supervisory rating is susceptible to all the sources of bias in objective indices, as well as to others that are irregular to subjective judgments. Bias in ratings may be due to spotty or inadequate observation by the rater, unequal opportunity on the part of subordinates to demonstrate proficiency, personal biases or prejudices on the part of the rater, or an inability to distinguish and reliably rate different dimensions of performance. The most frequently cited biasing factor in rating is the “halo” effect. The halo effect is when raters have a tendency to rate an individual either high or low on many factors because the rater knows (or thinks he/she knows) the individual to be high or low on a specific factor.

In education the outcome of exams and tests hold different meanings for lecturers and students. Different methods are used across tertiary institutions to assess academic performance. Academic performance can be assessed with class tests, semester tests, exams, participation marks and projects. Modern educational contexts are diverse but nevertheless groups still occur according to language, culture and ethnicity, creating opportunity for preference and bias when subjective judgements are used to measure academic performance (Bruce & Lack, 2009). Group Bias as explained above is most likely to occur in this study, due to students attending different tertiary institutions. According to a study done by Bruce and Lack (2009) subjective judgements are less accurate and valid than mathematical models, but it continues to be useful.

3.6 Summary

This chapter provides information on the LPCAT, ELSA and the mathematical proficiency test used in this study to predict academic success. It is important to understand the background of the predictors to gain insight into the purpose of the research study. The National Benchmark test project makes use of the mathematics proficiency and academic literacy in their studies. The academic literacy is similar to the ELSA done in this study. (Griesel, 2006). Research by Zaaiman (2002) takes mathematics and English proficiency into account, while research by Eiselen (2007) also takes mathematics into account. Loham (2005) studied the role of nonverbal ability tests in identifying academically gifted students. His research showed that verbal, quantitative (numeric literacy) and non-verbal reasoning should be tested for all students.

Background information on criterion related validly and criterion measures was also discussed as well as information on the current practices at tertiary level. The measurement instruments and research methodology used for this study will be discussed in Chapter 4.

Chapter Four: Research Methodology

4.1 Introduction

Chapter 4 aims to discuss the relevant research methodology and approaches used in this descriptive correlation study. This chapter provides information around the research approach, research design, the descriptive statistics used as well as the statistics used to analyse the data.

4.2 The purpose of the study

The purpose of this study is to determine the criterion related validity of literacy tests and a test for learning potential as predictors of academic performance for students in the field of science.

It needs to be established whether the chosen literacy tests and learning potential tests are predictive towards the academic success of tertiary students. This is important to determine in order for a company utilise the appropriate predictors in their selections. Not only will money be saved over the long run, but it will also ensure a valid, reliable and the fairest possible process for the future.

4.3 Research approach

A quantitative approach is used for the purpose of this study. The ELSA, LPCAT and Mathematical Proficiency tests (Academic Aptitude Test) were used to gather data. The research was conducted in the natural environment within South Africa. In quantitative research, the aim is to determine the relationship between one measure (an independent variable) and another (a dependent variable) in a population. Quantitative research designs are either descriptive (subjects usually measured once) or experimental (subjects measured before and after treatment).

More specifically, the Ex post facto analysis/design is used in this study. De Vos et al. (2003) defined ex post facto research design as that in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables. The ex post facto approach is extremely common, although it tends to be seen as a weaker design than a researcher would normally desire. This approach reduces the possibility that participants are influenced by the awareness that they are being tested.

A typical ex post facto study was done by Chapin (1995) in which the effect of high school education on future success of individuals after school was explored. Graziano and Raulin (2000) argue that the identification of contingencies is useful in suggesting hypothetical relationships. It however, does not provide the controlling factors needed to rule out the possibility that other factors may have on the relationship between variables.

Due to the independent variable that has already existed, no manipulation will take place. The purpose of the ex post facto research design is to explore possible causes and effects. Ex post facto design was used in this study because the experimental group already existed when a decision was taken to investigate the relationship between the different variables.

A cross-sectional study was also used in this study. Cross-sectional research is a design in which person or group is studied only once, consequent to some agent or treatment presumed to cause change (De Vos et al., 2004). In this study their academic performance over a 4 year period is investigated together with the outcome of their initial assessments before being awarded a bursary. Although data is gathered over a period of time it's a cross-sectional study due to the fact that it's only researched once.

In conducting this predictive study, the procedure is as follows:

- Measure candidates' language and mathematical ability as well as their learning potential.
- Select candidates based on the outcomes of the abovementioned assessment.
- Obtain information with regards to their academic results.
- Assess the strength of the relationship between the predictor and the criterion.

4.4 Sample

The sample for this study was pre-selected on more than one criterion. They were firstly selected on the grounds that they have met minimum criteria to qualify to attend a tertiary institution. Secondly, only students coming out on top with the assessments were monitored. The sample is thus of students who were all very close to each other in terms of academic achievements.

Due to the facts mentioned above, range restriction will occur. Range restriction occurs in the predictor when only the students who have survived the initial assessments are considered. The criterion data is unavailable for low scorers who did not get a bursary. This is known as direct range restriction (Cascio, 2005).

Three hundred and twenty nine (329) undergraduate students enrolled in BSc Engineering at various tertiary institution in South Africa were the subjects of this study. They are enrolled for various engineering disciplines namely chemical engineering, electrical engineering, electronic engineering, mining engineering and mechanical engineering. This was a convenient sample and the researcher collected data from every student successful in the bursary selection process.

A detailed discussion of the sample is provided in chapter 5.

4.5 Measurement Instruments

4.5.1 Introduction

The different measurement instruments used in this study will be discussed in this section. These tests were all developed in the South African context. This section provides a discussion of specifics around the measurement instruments in terms of its history and purpose.

4.5.2 English literacy skills assessment (ELSA)

The ELSA was designed and developed locally by Brian Hough and Theunis Horn in consultation with the Human Science Research Council (HRSC) in the late 1980s. ELSA is a South-African developed language, norm based (non syllabus based), group measuring instrument that can quantify and diagnose (Bhabha, Pott & Horn, 2006).

ELSA quantifies a respondent's English language and numeracy skills performance, equating the competency input performance level to that of a South African English mother tongue user. In diagnosing, it shows up an individual's strengths and areas for development in an English language work/training environment. It is essentially a prior learning and ABET placement guide for English and Functional Numeracy (Bhabha, 2006).

According to Bhabha (2006) the ELSA is a standardised, reliable and valid assessment with objective scoring. They are mainly verbal (written) assessments, including mixed power and speed testing.

ELSA norms are national and were established under the direction of the HSRC, using representative groups. A high level of predictive validity and reliability were measured. ELSA is culture fair in that it steers clear of meta language, colloquialisms, idiomatic expressions and dialectic usage and is cost effective (Bhabha, 2006).

This test is administered to individuals 16 years and older. The average time to complete this test is 80 minutes.

Areas of application

- Identify potential achievers in the workforce as well as those with poorly developed literacy skills. Once they've been identified, their skills can be upgraded.
- Ascertain and verify the literacy skills level of new recruits, in particular those for whom English is a second or third language.
- Help determine the literacy comfort zone of staff which, in turn, will enable the organisation to make its training manuals, in-house publications, standing instructions, IR procedures, etc. user friendly.
- Enhance communication and trainability.

4.5.3. Mathematical Proficiency

The mathematical proficiency test is part of the Academic Aptitude Test (AAT) for Universities. In 1968 the Department of Bantu Education expressed its need for a comprehensive test battery to be used in order to provide guidance to pupils with regard to further training (AAT Manual, 2008).

The AAT was developed in 1968 by the Human Science Research Council (HSRC). The specific developers of the test are R. Minnie, J.S. Gericke; F.W. Gericke; J.C. Chamberlain; B.P.A. Strauss.

The purpose of the mathematical proficiency test in particular is to determine whether a student has attained such a level of proficiency in Mathematics that he may immediately continue with the ordinary courses at university, or rather do a bridging course. The test consists of 30 items based on the Mathematics syllabus.

4.5.4. Learning Potential Computerised Adaptive Test (LPCAT)

The Learning Potential Computerised Adaptive Test (LPCAT) is a learning potential assessment as the name indicates. This assessment consists of only non-verbal items in an effort to counter the result of language ability and competency on test scores. Three types of items, namely explicit figure series, figure analogies and pattern completion are included in the test (Van Eeden, 2001). The test was developed by Marie de Beer in South Africa with a view to providing information on the present and potential future level of general non-verbal figural reasoning ability for persons from different backgrounds in a way that is fair to all concerned (de Beer, 2005). According to de Beer multicultural samples were used in its development and standardisation

In accordance with Item Response Theory (IRT), item difficulty and ability are measured on the same scale and the difficulty level of each item is determined beforehand. During testing, items are selected to match the estimated ability level of the individual. This indicates that each person can potentially be administered a unique set of items. However, with IRT, test scores are comparable, even when different sets of items are used for obtaining the scores (Van Eeden, 2001).

Item response theory principles and computerised adaptive testing technology addressed many of the earlier measurement problems in the dynamic assessment of learning potential and made possible the construction of a psychometrically sound, yet time-efficient and practically useful tool for the measurement of learning potential in multicultural contexts (de Beer, 2005).

Standard tests of cognitive ability generally measure the products of prior learning and hence rely heavily on the assumption that all examinees have had comparable opportunities to acquire the skills and abilities being measured (de Beer, 2005). Rather than restricting assessing the individual's present ability to respond to information already gained, the test embeds training in a test-train-retest sequence. This is referred to as dynamic testing and is based on Vygotsky's (1978) theory of the zone of proximal development (Van Eeden, 2001). It involves the measurement of the current level of ability (a pre-test) as well as the potential future level of ability (a post-test) following problem-relevant training or instruction within the test. The zone of proximal development refers to the difference between the level of achievement without help (actual developmental level) and the level of achievement with help (potential developmental level). The difference between these two provides an indication of the measure of undeveloped potential that is not readily available without some form of help. The difference in score should, however, not be regarded as a fixed value or a person's maximum potential for change; it is a fluctuating characteristic that may vary across time and is responsive to instruction (Brown & French, 1979).

Two types of the LPCAT are available. One version is a "text-on-screen" one, where respondents read the instructions and feedback by themselves (in English or Afrikaans), in the second version, no language appears on the screen and instructions are read to the examinees in any of the 11 official South African languages. The "text-on-screen" LPCAT can be used for respondents with an English and Afrikaans reading ability of at least Grade 6. For this version of the test, instructions, explanations and feedback on examples are provided in text format on the computer screen. No computer literacy is required, because only the space bar and enter key are used by the respondents (de Beer, 2000a).

The 270 new LPCAT items (90 of each item type) were initially administered for item analysis purposes to establish the item banks needed for adaptive testing. Item response theory procedures can use anchor items to combine samples for item analysis purposes, and to this end, 66 anchor items were used (22 of each of the item types figure series, figure analogies and pattern completion). Once the final version of the LPCAT in its computerised adaptive version had been constructed it was administered to different groups to obtain validity information (de Beer, 2000c; de Beer & van Eeden, 1997).

Differential item functioning analysis was performed to identify biased items in terms of level of education, gender, culture and language groups.

4.5.4.1 Reliability of the LPCAT

The classical indices of reliability namely test-retest reliability, parallel forms reliability and split-half reliability do not apply to computerised adaptive testing. This is because of the interactive selection of items from an item bank which results in different sets of items being administered to each examinee (de Beer, 2005). One classical test theory method of evaluating reliability that can be applied is the internal consistency or coefficient alpha index, which also reflects the homogeneity of content (Anastasi & Urbina, 1997).

The LPCAT has internal consistency reliability values ranging from 0.92 to 0.98 with reliability values above 0.9 for Coloureds, Africans and Whites as well as both males and females. The reliability for the LPCAT can thus be considered as satisfactory (Schoeman, 2002).

4.5.4.2 Validity of the LPCAT

The content and face validity of the LPCAT was judged to be satisfactory by a panel of test development experts involved in reviewing the development of the test (De Beer, 2000c).

In terms of construct validity, correlations were statistically highly significant and ranged between 0.400 and 0.645 for comparison with the Paper-and-Pencil Games (Claasen, 1996), and between 0.567 and 0.691 for comparison with the General Scholastic Aptitude Test (Claasen, De Beer, Hugo & Meyer, 1991) at the secondary school level. For the low literate adult group, correlations between LPCAT results and training results ranged between 0.398 and 0.610, while for a secondary school level sample, correlation of academic results and LPCAT performance ranged between 0.439 and 0.543 (De Beer, 2000c).

In another study with a group of students currently busy with a bridging course, the correlation of LPCAT and academic results ranged between 0.313 and 0.525 (De Beer, 2002). These results provide support for the validity of the LPCAT in the multicultural South African context.

4.6 Data collection procedure

The group completed the LPCAT, English Language Literacy Proficiency test (ELSA) and the mathematical proficiency of the Academic Aptitude Test (AAT) for University students. The three tests were done in a controlled and supervised environment by a trained test administrator / psychologist. The LPCAT was conducted in a computer lab. The ELSA and mathematical proficiency tests were paper-and-pencil administrated.

The “text-on-screen” version of the LPCAT test was used in this study. The reason for that is that the lowest level of education for any of the students was Grade 11.

4.7 The compilation of composite criterion scores

A composite criterion score was established for academic results across all levels of study. The composite criterion score consists of the subjects an individual had on that specific level (e.g. First year results). The year mark of the subjects were added up and divided by the number of subjects to get the average scores. All subjects carry equal weight. The data for this study was gathered over a period of 4 years. The first year results for the students were thus not gathered in the same calendar year. Further more, students are at different Universities, they don't have the same lecturers or the same subjects. They are all studying engineering, but the syllabus might vary from University to University. These are all contaminating factors.

4.8 Ethical considerations

All parties involved in a research study should exhibit ethical behaviour. The goal of ethics in research is to ensure that no individual is harmed or experiences unpleasant consequences from the research activities (Cooper & Schindler, 2003). To safeguard against unethical behaviour in this study, different actions were put in place.

Informed consent was gained from the students after explaining the purpose of the different measurement instruments to them. They also gave their consent that these results may be used for selection decisions. Another action taken to ensure that the study was done ethically, was the right to privacy. The results gained from the different measurement instruments were treated strictly confidential. Names, ID numbers or any other indication of who the person might be, were deleted from the study and not reported on at any stage.

4.9 Descriptive statistics

Descriptive statistics have a number of uses; firstly, to describe the sample. Secondly, to check the variables for any violation of the assumptions underlying the statistical techniques that were used to discuss the research question and lastly to address specific research questions (Pallant, 2007).

For the purpose of this study the descriptive statistics done were Frequencies. This provided information on the number of students, the number and percentage of different ethnic groups, the range and the mean of their ages.

Mean is an arithmetic average of all the values. A problem with this statistic is that extreme values often affect this value, creating distortion. Standard deviation is the square root of the variance, if the value is small, it implies that the data is close to its mean (Sham, 2008).

Kurtosis is a measure of the peakedness of the probability distribution of real-valued random variables. Higher kurtosis implies more of the variance is caused by infrequent extreme deviations, as opposed to frequent modestly-size deviations. Skewness measures the asymmetry of the probability distribution of a real-valued random variable. In a skewed distribution, the mean is not equal to the median. When there is no skewness, median, mean and mode are equal to each other (Joanes & Gill, 1998). It is important for researchers to notice skewness and kurtosis when in the dataset. When making decisions about the type of statistics to use, skewness and kurtosis give valuable information. Normality assumptions may be most critical. Normality can never be assumed and needs to be tested as this will have a major impact on the results obtained from the statistics.

The Kruskal-Wallis test was used in this study. The test assumes that the observations in each group come from populations with the same shape of distribution (Fagerland & Sandvik, 2009). For this study skewness and kurtosis were of utmost importance seeing that they indicate the shape of distribution.

4.10 Inferential statistics

4.10.1 Kruskal-Wallis Test

The Kruskal-Wallis test is the non-parametric substitute to a one-way between-groups analysis of variance. It allows the researcher to compare the scores on some continuous variable for three or more groups (Pallant, 2007). For this study it was important to see if the different tests discriminated between different groups of students, and thus have a predictive value.

The Kruskal-Wallis can be done on categorical data. For that reason the Kruskal-Wallis was done for the ELSA. Categorical data can't be used for correlation analysis. The Kruskal-Wallis analysis was also performed for LPCAT and the Mathematical literacy test, which helped with identifying the discrimination value of each predictor. Normal distribution is not assumed for the Kruskal-Wallis, although not having the same shape of distribution might have a negative effect on the results.

4.10.2 Pearson Correlation Coefficients

There are many different methods of determining correlation or relationship between variables and these depend primarily on the measurement scale of the variables being compared. The correlation coefficient is a measure of the degree to which the points tend to cluster about a straight line. The correlation coefficient measures the degree of linear relationship between the x and y value (Sham, 2008).

The most common measure of "correlation" or "predictability" is **Pearsons correlation coefficient,** which is expressed in r. The value can be anywhere between -1 and 1. The larger r, irrespective of the sign, the stronger the relationship between the two variables and the more accurately you can predict one variable from the other variable. A correlation of 1 or -1 means that the two variables are perfectly correlated. This implies that one can predict the values of one variable from the values of the other variable with perfect accuracy. An r of zero implies an absence of a correlation - there is no relationship between the two variables. This implies that knowledge of one variable gives you absolutely no information about what the value of the other variable is likely to be (Price, 2000).

The sign of the correlation implies the "direction" of the association. A positive correlation implies that relatively high scores on one variable can be paired with relatively high scores on the other variable, and low scores can be paired with relatively low scores. A negative correlation, on the other hand, implies that relatively high scores on one variable are paired with relatively low scores on the other variable (Price, 2000)

Correlation was used in this study to see whether a relationship is present between academic performance and the LPCAT as well as Mathematical proficiency test scores. In order to perform the test for Pearson correlation Coefficients a number of assumptions need to be met (Pallant, 2007):

- Level of measurement - the scale of measurement should be interval or ratio.
- Related pairs – each subject must provide a score on all the variables
- Independence of observations – the observations that make up the data must be independent of one another. Each observation or measurement may not be influenced by another observation or measurement.
- Normality - scores on each variable should be normally distributed
- Linearity – the relationship between variables should be linear

- Homoscedasticity – the variability in scores for one variable should be similar at all values of the other variable.

These assumptions are met in this study.

4.10.3 Regression analysis

Regression analysis is a statistical technique used for the investigation of relationships between two or more quantitative variables (Sykes, 2003). It is normally used where the researcher tries to find the causal effect of one variable upon another. To investigate this effect, the researcher gathers data on the underlying variables of interest and utilises regression to estimate the quantitative effect of the causal variables upon the variable they influence. Regression is also used to assess the statistical significance of the estimated relationship (Sykes, 2003).

There are many different types of regression analyses. For the purpose of this study, simple linear regression as well as multiple regression were used. The assumptions necessary for these types of regression according to Pallant (2007) are:

- A relatively large sample size is needed, to enable generalisation of the results
- Multicolinearity and singularity which refer to the relationship of the independent variable. These types of relationships are unsatisfactory for multiple regression, as this will not contribute to a good regression model.
- Multiple regression is very sensitive for outliers
- Normality, Linearity, Homoscedasticity, independence of residuals need to be intact.

Assumptions were met and regression analysis was used in this study to understand the statistical dependence of one predictor on another.

4.11 Statistical program used

The Statistical analysis systems program (SAS) version 9.1.3 was used in conducting the data analysis for this study (SAS Institute Inc, 2004).

4.12 Summary

This chapter provides information on the specific measurement instruments as well as the types of statistical analyses used in this research in order to provide a basis for the discussion of the results. It is important to understand the use of the different tests to gain insight into the extent to which it can help with this research finding. Chapter 5 contains the articles relevant to this study, which also includes the discussion of the results.

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Chapter 5

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LEARNING POTENTIAL AND ACADEMIC LITERACY TESTS AS PREDICTORS OF ACADEMIC PERFORMANCE FOR ENGINEERING STUDENTS

MONICA LOGIE

PIETER SCHAAP

pieter.schaap@up.ac.za

Department of Human Resource Management

University of Pretoria

ABSTRACT

The aim of this study was to evaluate a battery of tests to be used as part of the process of selecting bursary students for engineering at tertiary institutions. Due to the problems in the schooling system it is not conclusive that all students who have obtained their senior certificates are prepared and able to meet the demands and challenges of tertiary education. The purpose of this study was to determine the criterion related validity of a mathematic proficiency test, Learning Potential Computerised Adaptive Test (LPCAT) and English Literacy Skills Assessment (ELSA) as predictors of academic performance. A quantitative approach was used for the purpose of this study. More specifically the Ex post facto analyses/design is used in this study. The relationships between the dependent and independent variables were determined. Correlation analyses, Kruskal-Wallis test and regression analysis were used for the purpose of this study. The results indicated that the Mathematical proficiency test was the best predictor of academic success, followed by LPCAT and ELSA. The results of this study indicates that the use of academic literacy and learning potential contribute in selecting the best students. Companies and Universities have long been looking for a predictor or predictors of success for students as they enter tertiary studies. This information has the potential to save companies and universities millions of Rands annually by helping them make better investment decisions.

Development of human capital serves not only the economic interest of the company itself, but also the broader requirements of the society within which the company operates.

The selection of students is a critical issue currently facing South Africa. Changes and inequities in the South African educational system have intensified the need for proven valid and fair selection (Zaaiman, van der Flier & Thijs, 2000). After the first democratic election in 1994, all South Africans gained equal rights to education. The outcome based school system was also introduced shortly after the election. A major challenge emerged for the government of national unity in 1994 to get education policies into place that would help undo the legacy of apartheid, and which would result in the establishment of a higher education system that would address the imperatives of transformative conditions such as equal access, development, accountability and quality (Waghid, 2002).

Selection decisions are often based upon a combination of qualitative and quantitative evidence (Brashears & Baker, 2001). Qualitative evidence can include leadership and achievements in high school as well as the structured interview at bursary selection. Quantitative evidence is typically school or university results.

Up to now quantitative evidence was used in making bursary selections. Miller (1992) refers to this system as using the past to predict the future: in the past this method appeared to have been a good and consistent indicator of future academic success. Matriculation results were a surprisingly excellent indicator of subsequent academic success for first year intake of students. (Badenhorst, Foster & Lea, 1990; Potter & van der Merwe, 1993a; Jawitz, 1995) The traditional practice as mentioned above of using matriculation results as the most important source for tertiary entrance requirements is still leading. This practice is based on the assumption that school academic performance is a useful and reliable predictor of performance at tertiary level (Ngidi, 2007).

The difference in educational opportunities at school level complicates the use of school results. It also complicates the development of fair and effective selection mechanisms (Zaaiman, 2000). The present situation affords a large petrochemical company the unique challenge in finding a test battery for selection purposes that is justifiable, yet practical and useful in the challenges of finding suitable bursary candidates.

Need for Engineers

From 2005 there has been a huge increase in projects, especially from government infrastructure e.g. road improvement projects and reconstruction and development programme's. The FIFA Word Cup taking place in South Africa is also placing a big demand on the industry, due to improvements that need to be made to current infrastructure (Inngs, 2007). Due to this, the market demand for skilled workers in the field of science, e.g. engineers, is set to increase substantially. Van Reenen quoted that Ngcobo (2008) indicated that research done by Department of Trade and Industry revealed a possible shortage of 1.5 million to 2 million skilled workers by 2017.

This is the case in South Africa as well as other countries, with a huge global demand for infrastructural services, creating a huge demand for engineers. With the current skills shortage in South Africa, the number of graduates needs to be increased to make up the shortage (The National Skills Development Handbook, 2007).

The demand in the labour force for students graduating in the field of science, engineering and technology, is reinforce by the fact that it is the key objective of the South African National Plan for Higher Education to shift the balance of enrolment to tertiary studies from the humanities to business and commerce and most of all to science, engineering and technology (Department of Education, 2001).

Problem statement

Human resources are an important factor of production and have a direct impact on the competitiveness of firms (Kleynhans, 2006). The development of human capital within a large petrochemical company is a key driver for competing successfully in a modern global economy. Human capital is those elements in humans that enhance the quality of labour, such as skills, knowledge and wisdom (Kleynhans, 2006). As a large petrochemical company continues to grow in stature as a major regional player in Southern Africa and, increasingly, as an international competitor in select areas of fuel and chemical production and marketing, the attraction and development of talent, especially in the field of science are key factors to the continued success (le Roux, 2006). The enhancement in the quality of the human resources entering the company can lead to lower costs (Kleynhans, 2006).

High school results have been used in the past and very often been found to be a good indicator of subsequent academic and work performance, although care should be taken when these marks are used as the primary selection information. According to Nunns and Ortlepp (1994), the use of school results of South African students who are not disadvantaged is justifiable. But the results of local research on relatively disadvantaged students are less convincing. As Shochet (1994) argues, results obtained in a disadvantaged social and educational system, cannot accurately reflect academic potential. An assumption of Griesel (2006) also underpins the need for proficiency tests for entry level into tertiary institutions due to the fact school leaving results might give an incorrect reflection of a student's cognitive skills.

Given the unpredictable profile of students it is not conclusive that all students who have obtained their senior certificates are prepared and able to meet the demands and challenges of tertiary education. In that light, an academic literacy test should be deemed essential in providing insight into the intellectual profile and academic readiness of students (Scholtz & Allen-ile, 2007). Suitable and timely interventions based on the results and analysis of selection tests could implicate far-reaching positive and financial implications for the individual by becoming economically productive, for the institutions by improving through-put rates and subsidies and for the country as a whole by contributing to the economic advancement in South Africa.

Additional assessment is necessary to conduct the fairest possible selection process. Testing and assessments are synonymous with determining advancement in education. No matter the purpose of the test, the aim of testing is to determine the test taker's ability to perform at a specific level in a specific discipline (Scholtz & Allen-ile, 2007). The first consideration when assessment measures are selected is the fact that it should differentiate between the academic needs of students who currently show academic excellence and the needs of those who show less significant accomplishments, but have the potential for developing academic excellence (Lohman, 2005). For that reason the Learning Potential Computerised Adaptive Test (LPCAT) was included in this study. LPCAT is a learning potential test.

Using only the interview will not suffice. The typical review of interview literature concludes that the validity of interviewer judgements was too low to be of value in selections. Over the past years meta-analyses have led to more optimistic conclusions but also show that there is significant room for improvement when using interviews for selection purposes (McDaniel, Whetzel, Schmidt & Maurer, 1994). While interviews can be a useful tool to gain information, it does, however, have a number of weaknesses. The reason for this is in the fact that interviews are an unstandardised assessment procedure (Dipboye, Gaugler, Hayes &

Parker, 2001). Even if the same questions were asked, the interpretation will differ. It is therefore important that more than one person interview a specific student.
Assessment test results can be represented numerically, making it easy to compare applicants with each other. These tests provide a range of information which is not easily and reliably assessed in other ways. Information like this can fill important gaps which have not been assessed by application forms or interviews.

Purpose Statement

This research aims to explore the relationship between students' academic performance (as assessed on their marks for specific modules as well as year averages) and two different types of tests measuring cognitive ability (LPCAT) and academic literacy (ELSA & Mathematics).

In the next sections high school performance as an entrance requirement to tertiary institutions will be discussed, as well as current practices for admission tests by different tertiary institutions. This will highlight the need for additional tests as well as current practices among institutions in selecting students.

High School performance as entrance requirement to University

Entrance to South African tertiary education was gained through the possession of a matriculation school-leaving certificate. A score was awarded to a specific subject grade. If a sufficient score was obtained, and, in some disciplines, specific subjects' pass requirements were met, entrance to the tertiary institution was allowed.

The long-established practice of using matriculation results as the prime basis for university entrance is still leading. This practice is based on the assumption that school academic performance is a useful and reliable predictor of performance in higher education. However, the fact that there are high drop-out rates and low graduation rates in many South African universities shows that this assumption is not absolutely true. Badenhorst, Foster and Lea (1990) indicate that predictability of the matriculation results appears to vary from one tertiary institution to another. This is in line with claims that school achievement has very limited value as a predictor of student success in tertiary education (Ngidi, 2007).

Enrolment for standard grade mathematics has increased significantly in recent years, but the pass rate in 2003 was only 44.7 per cent. Conversely, the pass rate in higher grade

mathematics has improved – but enrolment has plummeted, from 65 616 in 1995 to 35 959 in 2003 (Clynick & Lee, 2004). The same pattern is followed in physical science.
In 2003, the system produced only 2 735 more HG mathematics students passing than it did in 1991. The same is true for HG science in 2003 - there were only 2 958 students more passing than in 1991 (Clynick & Lee, 2004). This poses an increasingly difficult challenge to find suitable candidates to award bursaries to.

The mathematics results for the group of grade 12 students matriculating in 2008 were exceptionally high and many more students qualified for university entrance. 63 000 (2009) compared to 25 000 (2008). Although there were significantly more students qualifying for university entrance, the first semester mathematics related results for 2009 first year students at tertiary institutions were disturbing (Huntley, 2009). These were the first students receiving Outcome Based Education. The syllabus at tertiary level for Engineering studies hasn't changed. The only variable is the type of education students received prior to entering into University. There might be many reasons why students were not performing as in previous years. For the purpose of this study the reasons will not be investigated.

Course	**June 2008**		**June 2009**		**National Senior Certificate level**
	Student no	**Pass rate**	**Student no**	**Pass rate**	**Min**
Mathematics Statistics 1	170 (capped)*	51%	170(capped)*	29%	7(A)
Mathematics 1 Major	419	50%	652	31%	6(B)
Mathematics 1 Engineering	666	71%	1239	35%	5(C)
Ancillary Mathematics & Statistics 1	369	75%	453	60%	4(D)

* The sample was restricted to 170

Proficiency tests in tertiary institutions

A variety of reasons may be given for conducting proficiency tests in academic literacy at tertiary education institutions. According to Weideman (2002), most tertiary intuitions in South Africa have introduced some form of analytical selection tests in reaction to the concern about the academic literacy levels of first year students. A lack of ability in academic literacy could put students at risk of not completing their courses in the minimum time, which has a cost implication for the institution as well as the students or the person supporting the student financially (Scholtz & Allen-ile, 2007).

Proficiency tests are used at various institutions of higher learning in South Africa. The Standardised Assessment Test for Access and Placement (SATAP) is used by the Cape Peninsula University of Technology (CPUT). The University of Cape Town has established the Alternative Admission Research Project (AARP), while the University of Pretoria has the Test of Academic Literacy Levels (Weideman, 2002). One or more of these tests are used as an assessment battery by different tertiary institutions in South Africa.

Placement and selection tests are not unique to the tertiary education in South Africa. The United States of America witnessed an exceptional number of students applying for limited places at colleges and universities. About 2.6 million students wrote one or more standardised assessment test to qualify for entrance, out of an annual high school graduating class of 3 million nationally (Greene & Greene, 2004). As is the case in South Africa, the US institutions have varying entrance examination and admission policies (Scholtz & Allen-ile, 2007).

An indication of the urgency and importance of determining the academic preparedness of entry-level students, the former South African Universities Vice-Chancellors Association (SAUVCA) and the Committee of Technikon Principals (CTP) approved the proposal of the National Benchmark Test (NBT). Benchmarks are an indication of the expected level of academic literacy that students should attain and that all learners should reach certain grade levels for tertiary entry. According to Foxcroft (2006) it is a point of reference for evaluating and monitoring the adequacy of achievements and educational development of learners.

Proficiency tests for selection and placement purposes have become accepted practice at most higher tertiary institutions in South Africa (Scholtz & Allen-ile, 2007).

The value of different proficiency tests

The value of language, numeric ability and learning potential with regards to academic success will be investigated next. These three areas were identified as predictors for academic success for the purpose of this study. The test battery is based on these elements.

- **Language**

The term "proficiency", with regards to language usage in different contexts, has a variety of meanings and connotations. Bachman (1990) points out that the traditional view of language proficiency referred to the competence, knowledge or the ability to use a language. Subsequently, "communicative language ability", "communication competence" and "communicative proficiency" have all been used to refer to language proficiency. Bachman (1990) views academic proficiency within the context of communicative ability. Communicative ability is more than the transfer of information - it requires interaction between the situation, the language user and the dialogue. Lea and Street (1998) point out that learning in tertiary education involves becoming accustomed with new ways of knowing. In fact, it is new ways of understanding, interpreting and organising knowledge, by making conclusions, form and express opinions, employ critical thinking and reading skills, to form arguments and establish an individual point of view.

The ongoing problem of poor academic performance of many students at primary, secondary and tertiary level is disconcerting, especially in science and mathematics. The theoretical complexity and problem solving environment of these disciplines make a wide-range of demands on the reasoning, interpretive and strategic skills of students, especially when practiced in a language that is not the student's first language (Bohlmann & Pretorius, 2002).

As long ago as 1987, Dale and Cuevas (1987) pointed out that the proficiency in the language in which mathematics is taught, especially reading proficiency, was a prerequisite for mathematics achievement. During 2000, an interdisciplinary reading skills project was launched by the Departments of Mathematics and Linguistics at Unisa. The aim of the study was to assess the reading skills of mathematics students, and to explore the relationship between reading skills and performance in mathematics. The findings showed a robust relationship between reading ability and mathematics performance (Bohlmann & Pretorius, 2002).

Webb (2002) indicated that language is fundamental to educational development in at least two ways:

1. It is a fundamental instrument in students' cognitive, affective and social development; and
2. It is an essential object of teaching, in the sense that becoming academically trained implies learning to use the language of the specific science appropriately in professional contexts, as well as learning to use language for general purposes.

Educational development is also concerned with the gaining of knowledge, with integrating new knowledge into the existing bases of knowledge, with gaining the rules that govern the storage and retrieval of information, with grasping scientific and scholarly concepts and learning the terms for these concepts, with understanding the processes and principles of a particular field of learning, and with using these concepts and principles to solve problems. Academic training also means being able to gather information/data, accept its analysis and interpretation, and manage it in problem-solving. It means to learn to discover patterns and rules, to reason, to identify a scientific fact, to test a suggestion, to identify, construct and evaluate scientific arguments, to find plausible and coherent explanations for phenomena and to evaluate points of view and ideas critically.

These high-level cognitive, affective and social skills do not generally develop in a “spontaneous” way. As Hernandez (1993) points out, cognitive and meta-cognitive skills are acquired “through social interaction (with experts in the field) where comprehensible communication occurs and active awareness of these comprehension problems and problem-solving strategies is demonstrated.” This applies to social and affective skills. The development of these skills is reliant on language.

The role of language is even more important taking into account the background of multilingualism and cultural heterogeneity as is the case in South African Universities. South African universities, in particular the historically white institutions, have become linguistically and culturally considerably divers. This implies that many of their students come from social worlds which differ significantly from the world of these institutions, especially in the sense of having been less exposed to the values, norms, behaviour patterns, and so forth, presupposed by the institution. These differences could imply situations of conflict, resulting in experiences of unfriendliness and insecurity. In such situations, language plays an important mediatory role (Webb, 2002)

Consideration should also be given to second-language students and how it relates to the effect of the social meaning of first languages. Ervin-Tripp (1970) points out that users of the minority languages are disadvantaged to the degree in which they experience a sense of inferiority, have low expectations of their own achievements, have a negative perception of the power of their own social group, receive or do not receive respect for their first languages, and by the degree to which they are expected to compete with native speakers.

Linguists (John, 1970; Ervin-Tripp, 1970; Freeman, 1998), who have researched the role of language in academic success as well as Angelil-Carter (1998) a South African academic, agree in principle that it is extremely difficult to be specific about the contribution of the language factor to learning, seeing that there are many factors of equal or greater importance involved in the processes. Nevertheless, as indicated by Webb (2002), language may be an important factor, and it needs to be properly considered.

If further consideration is given to the fundamental role of language, linguistic behaviour is critical in professional occupations, and the proficiency in language is non-negotiable for competitiveness in the national and international marketplace. It is thus self-evident that the issue of language proficiency in academic development and assessment across all disciplines is serious.

The abovementioned is gained from the conclusions by Lemmer (1991) about the consequences of inadequate proficiency in the language of learning and training at tertiary level. Lemmer (1991) points out those speaking minority languages usually suffer serious effects such as poor academic achievements as well as poor foundation for cognitive development and academic progress.

This point of view of Lemmer is shared by other researchers. The value of language in tertiary education was researched by Zaaiman, van der Flier & Thijs (2002) on students at the University of the North. Their research findings indicate a significantly high predictive validity for students who were successfully selected based on language proficiency tests. Webb (2002) conducted a similar study at the University of Pretoria, researching the importance of language proficiency and the effect of second language at tertiary institutions. The study of Webb (2002) proved that inadequate language proficiency hinders meaningful participation in class and note-taking. The inadequate guidance to students about handling language problems can result in students performing below their potential and might result in failing of courses.

Language proficiency can thus be described as fundamental in academic training, as it can either facilitate academic development, or serve as a barrier

- **Numerical ability**

In spite of the fact that mathematics is the foundation of scientific literacy, many South African students do not perform sufficiently in this subject. Adopting an Outcomes Based Education (OBE) approach has not contributed to an improvement of the situation (Maree & Lana, 2007).

Due to its widely accepted predictive validity, passing mathematics in Grade 12 is regarded as an admission requirement for undergraduate studies in the fields of science, engineering and technology. This is not an experience that is unique to SA (Furner & Bernan, 2003). Mathematics can be described as the first step to careers in science, engineering and technology (Furner, 2003). Admission requirements based on Grade 12 results are a contentious issue due to the historical differences in the education systems at schools (Skuy, 1996; Department of Education, 2003).

At the University of Pretoria they became aware of the lack of understanding of first year students in terms of fundamental mathematical concepts. In addition to that, the lack of competence in communication skills, especially technical (including mathematical) communication skills was also noted (Du Preez, Steyn & Owen, 2008). A similar observation was made in the United States where a survey revealed that an increasing number of students needed remedial courses in mathematics and English (Graff & Leiffer, 2005).

A study on a basic mathematical skills test as a predictor of performance at tertiary level for students studying in science and engineering was done by Eiselen, Strauss and Jonck (2007). This study provided support for the use of an assessment, independent of Grade 12 results, for the measurement of basic mathematical skills of students entering into tertiary education. The mathematical skills test showed to be a significant predictor of success, especially in the first semester of tertiary training.

- **Value of learning potential as predictors**

To ensure that training and education are aimed at potentially the most responsive and deserving students, it is necessary that such students have the potential to develop. The measurement of learning potential, rather than the measurement of inherent and learned aptitudes, is progressively more used in South Africa for the assessment of cognitive functioning (Murphy, 2002). Many cognitive assessments can potentially cause problems, because they measure only current cognitive abilities, and do not measure students' capacity to gain skills, strategies and operations in new situations (Foxcroft, 1997). This initiated the techniques referred to as culture-fair, such as learning potential assessment (Murphy 2002; Taylor, 1994).

To deal with the shortcomings of traditional intelligence testing, learning potential assessment has been developed as an alternative strategy for the assessment of cognitive functioning (Murphy 2002). Learning potential assessment measures individuals' current levels of ability as well as their potential for improvement with help. Learning potential tests are standardised to ensure measurement accuracy to allow for comparison between individuals. This assessment can be used for selection purposes. These assessments focus on existing and improved levels of functioning to evaluate the capacity for gaining new skills or knowledge when training is provided (De Beer, 2005).

Some of the limitations mentioned with regards to non-verbal assessments are that many learning potential applications use standardised psychometric instruments in nonverbal format, thus not using instruments specifically developed for nonverbal assessment. In nonverbal assessment, the role of the examiner varies from very important (clinical diagnostic orientation) to more limited (measurement or psychometric orientation). In general, the more clinical and unstandardised the approach, the less comparable the results of different individuals become (De Beer, 2006).

To determine which characteristics are important when assessing with the help of a selection test, necessitates careful consideration of the knowledge, skills, motivation, and other personal attributes that are required for success in that particular academic program (Lohman, 2005).

In an effort to provide more equitable, cognitive assessment in the last few decades, nonverbal assessment and the measurement of learning potential have received increasing attention both locally and internationally (Murphy, 2006). Nonverbal assessment was for the first time intensively researched in the 1960s and 1970s with the purpose to firstly provide more culture-fair assessment; secondly be useful for comparing results obtained in culturally diverse populations; thirdly be appropriate for testing individuals with deprived education experiences; and lastly it could measure learning potential distinct from what has been learned – regardless of the culture, population, or social group of tested individuals (De Beer, 2006). The abovementioned are the reasons for including the learning potential test as part of the selection battery.

Van Eeden, De Beer and Coetzee (2001) investigated cognitive ability, learning potential, and personality traits as predictors of academic achievement by engineering and other science and technology students. Correlation with the criterion as well as the regression analyses indicated that school achievement was the best cognitive predictor of average first-year performance. Of the psychometric tests, the General Scholastic Aptitude Tests (GSAT) seemed to be a good predictor of first-year performance. The pre-test and post-test of the Learning Potential Computerised Adaptive Test (LPCAT) did not seem to predict academic success. However, this test aims to measure modifiability, and it should be used for identifying students who will benefit most from a support programme rather than those who are already performing at a specific level. Lohman (2005) gave similar feedback after his study on non-verbal ability tests. He indicated that nonverbal/figural reasoning abilities should be used as a helpful adjunct, but not as the last resort or only measurement instrument.

Specific predictors (literacy tests and learning potential) used in this study were discussed in the preceding section. It is important to understand the background of the predictors to gain insight into their purpose in this research study. The National Benchmark test project makes use of the same predictors (Griesel, 2006). Research by Zaaiman (2002) as well as research by Eiselen (2007) also take these predictors into account. Loham (2005) studied the role of nonverbal ability tests in identifying academically gifted students. His research showed all students should be tested for verbal, quantitative (numeric literacy) and non-verbal reasoning.

RESEARCH DESIGN

Research approach

A quantitative approach is used for the purpose of this study. The ELSA, LPCAT and Mathematical Proficiency test (Academic Aptitude Test) were used to gather data. The research was conducted in the natural environment within South Africa. In quantitative research the aim is to determine the relationship between one measure (an independent variable) and another (a dependent variable) in a population. Quantitative research designs are either descriptive (subjects usually measured once) or experimental (subjects measured before and after treatment).

More specifically the Ex post facto analysis/design is used in this study. De Vos et al. (2003) defined ex post facto research design as that in which the independent variable or variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables. The ex post facto approach is extremely common, although it tends to be seen as a weaker design than a researcher would normally desire. This approach reduces the possibility that participants are influenced by the awareness that they are being tested.

A typical ex post facto study was done by Chapin (1995) in which the effect of high school education on future success of individuals after school was explored. Graziano and Raulin (2000) argue that the identification of contingencies is useful in suggesting hypothetical relationships. It however, does not provide the controlling factors needed to rule out the possibility that other factors may have on the relationship between variables.

Due to the independent variable that has already existed, no manipulation will take place. The purpose of the ex post facto research design is to explore possible causes and effects. Ex post facto design was used in this study because the experimental group already existed when a decision was taken to investigate the relationship between the different variables.

A cross-sectional study was also used in this study. Cross-sectional research is a design in which person or group is studied only once, consequent to some agent or treatment presumed to cause change (De Vos et al., 2004). In this study their academic performance over a 4 year period is investigated together with the outcome of their initial assessments before being awarded a bursary. Although data is gathered over a period of time it's a cross-sectional study due to the fact that it's only researched once.

In conducting this predictive study, the procedure is as follow:

- Measure candidates' language and mathematical ability as well as their learning potential.
- Select candidates based on the outcomes of the above mentioned assessments.
- Obtain information with regards to their academic results.
- Assess the strength of the relationship between the predictor and the criterion.

Research method

Sample

The sample for this study was pre-selected on more than one criterion. They were firstly selected on the grounds that they had met minimum criteria to qualify to attend a tertiary institution. Secondly, only students coming out on top with the assessments were monitored. The sample is thus of students who were all very close to each other in terms of academic achievements.

Due to the facts as mentioned above, range restriction will occur. Range restriction occurs in the predictor when only the students who have survived the initial assessments are considered. The criterion data is unavailable for low scorers who were not awarded a bursary. This is known as direct range restriction (Cascio, 2005).

The subjects of this study were three hundred and twenty nine (329) undergraduate students enrolled in the fields of science at any tertiary institution in South Africa. This was a convenient sample and the researcher collected data from every student successful in the bursary selection process. These bursary students had completed the ELSA, LPCAT and mathematical proficiency tests. All the data was gathered with the informed consent of the students and under the supervision of a registered psychologist. All information was dealt with in a confidential manner.

The biographical information is set out in Table 1 and Table 2.

	N	%
Gender		
Male	207	37.08
Female	122	62.92
Total	**329**	**100**
Year of study		
Grade 12	199	60.67
1st year	87	26.52
2nd year	37	11.28
3rd year	5	1.52
Total	**329**	**100**
Ethnic group		
Black	73	22.19
Coloured	13	3.95
Indian	84	25.53
White	159	48.33
Total	**329**	**100**
University		
University of Witwatersrand	39	11.85
University of Cape Town	34	10.33
University of Johannesburg	6	1.82
University of Kwazulu-Natal	73	22.19
North-West University	47	14.29
University of Pretoria	97	29.48
University of Stellenbosch	33	10.03
Total	**329**	**100**

Table 1 Descriptive statistics for the sample

Variable	N	Mean	Std Dev	Min	Max
Age	329	20.97	1.25	19	28

Table 2 Descriptive statistics for the age of the sample

The sample consisted of 73 Black, 13 Coloured, 84 Indian and 159 White respondents. The majority of the bursary students are males (62.92%), and 37.08% are females. The ages of the sample vary from nineteen years (19) to twenty eight years (28) with a mean of 20.97.

Various Universities in South Africa were represented in this study. Most of the respondents (29.48%) were from the University of Pretoria, while 22.19% of the students were from the University of Kwa-Zulu Natal. Other Universities that were represented in this study were the North-West University (14.29%), the University of Witwatersrand (11.85%), the University of Cape Town (10.33%), the University of Stellenbosch (10.03%) and the University of Johannesburg (1.82%).

The majority of the respondents were Grade 12 learners (60.67%) when the bursaries were awarded, while the 26.52% were first year students, 11.28% 2nd year students and 1.52% 3rd year students.

Measuring instruments

The different measurement instruments used in this study will be discussed in this section. These tests were all developed in the South African context. This section provides a discussion of specifics around the measurement instruments in terms of its history and purpose.

- **English Literacy Skills Assessment (ELSA)**

The ELSA was designed and developed locally by Brian Hough and Theunis Horn in consultation with the Human Science Research Council (HRSC) in the late 1980s. ELSA is a South-African developed language, norm based (non syllabus based), group measuring instrument that can quantify and diagnose (Bhabha, 2006).

ELSA quantifies a respondent's English language and numeracy skills performance, equating the competency input performance level to that of a South African English mother tongue user. In diagnosing, it shows up an individual's strengths and areas for development in an English language work/training environment. It is essentially a prior learning and ABET-placement guide for English and Functional Numeracy (Bhabha, Pott & Horn, 2006).

According to Bhabha, Pott & Horn (2006) the ELSA is a standardised, reliable and valid assessment. The scoring is objective and the functions are mastery, survey and diagnostic. They are mainly verbal (written) assessments, including mixed power and speed testing.

ELSA norms are national and were established under the direction of the HSRC, using representative groups. A high level of predictive validity was measured in terms of the predicting value for academic performance. ELSA is culture fair in that it steers clear of meta language, colloquialisms, idiomatic expressions and dialectic usage and is cost effective (Bhabha, Pott & Horn, 2006).

- **Mathematical Proficiency**

The mathematical proficiency test is part of the Academic Aptitude Test (AAT) for Universities. In 1968 the Department of Bantu Education expressed their need for a comprehensive test battery to be used in order to provide guidance to pupils with regards to further training (AAT Manual, 2008).

The AAT was developed by the Human Science Research Council (HSRC). The specific developers of the test are R. Minnie, J.S. Gericke; F.W. Gericke; J.C. Chamberlain; B.P.A. Strauss.

The purpose of the mathematical proficiency test in particular is to determine whether a student has attained such a level of proficiency in Mathematics that he may immediately continue with the ordinary courses at university, or rather do a bridging course. The test consists of 30 items based on the Mathematics syllabus.

The final norms for the AAT were established in February and March 1975, the final form of the AAT was applied to 947 first year students at three different Universities.

- **Learning Potential Computerised Adaptive Test (LPCAT)**

The Learning Potential Computerised Adaptive Test (LPCAT) (De Beer, 2005) is a learning potential assessment as the name indicates. This assessment consists of only non-verbal items in an effort to counter the result of language ability and competency on test scores. Three types of items, explicitly figure series, figure analogies and pattern completion are included in the test (Van Eeden, 2001).

Normally test reliability coefficients of 0.80 and higher are regarded as acceptable. LPCAT has internal consistency reliability values ranging from 0.92 to 0.98. LPCAT also has reliability values above 0.9 for Coloured, African and White respondents as well as for male and female.

The content and face validity of the LPCAT was judged to be satisfactory by a panel of test development experts involved in reviewing the development of the test (De Beer, 2005).

In terms of construct, validity correlations were statistically highly significant and ranged between 0.400 and 0.645 for comparison with the Paper-and-Pencil Games (Claasen, 1996), and between 0.567 and 0.691 for comparison with the General Scholastic Aptitude Test (Claasen, De Beer, Hugo & Meyer, 1991) at secondary school level. For the low literate adult group, correlations between LPCAT results and training results ranged between 0.398 and 0.610, while for a secondary school level sample, correlation of academic results and LPCAT performance ranged between 0.439 and 0.543 (De Beer, 2005).

The compilation of composite criterion scores

A composite criterion score was established for academic results at first year level. All subjects carry equal weight. The data for this study was gathered over a period of 4 years. The first year results for the students were thus not gathered in the same calendar year. Furthermore, students are at different Universities, they don't have the same lecturers or the same subjects. They are all studying engineering, but the syllabus might vary from University to University. These are all contaminating factors.

When a composite criterion is used, the purpose of the study must be taken into account. While composite criterion might valuably represent and predict an underlying economic dimension, it might not be true from a behavioural studies perspective (Cascio, 2005). Composite criterion makes sense after correlations among criteria are evaluated. Composite criteria might bring down the predictive validity of the predictors.

According to Cascio (2005), the use of composite criterion versus multiple criteria depends on the purpose of the study. When the goal of the study is to increase psychological understanding of predictor-criterion relationships it is best to keep the criteria separate. But when the objective is decision making, the criteria must be calculated into a composite score.

Research procedure

The group completed the LPCAT, English Language Literacy Proficiency test (ELSA) and the mathematical proficiency of the Academic Aptitude Test (AAT) for University students. The three tests were done in a supervised environment by a trained test administrator / psychologist. The LPCAT was conducted in a computer lab. The ELSA and mathematical proficiency were paper and pencil administrated. The “text-on-screen” version of the test was used in this study. The reason for that being that the lowest level of education for any of the students was Grade 11.

In conducting this predictive study, the procedure is as follow:

- Measure candidates’ language – and mathematical ability as well as their learning potential.
- Select candidates based on the outcomes of the above mentioned assessment.
- Obtain information with regards to their academic results.
- Assess the strength of the relationship between the predictor and the criterion.

Statistical techniques

- **Descriptive statistics**

Descriptive statistics have a number of uses; firstly, to describe the sample. Secondly, to check the variables for any violation of the assumptions underlying the statistical techniques that were used to discuss the research question and lastly to address specific research questions (Pallant, 2007).

For the purpose of this study the descriptive statistics done was Frequencies. This gave information on the number of students, the number and percentage of different ethnic groups, the range and the mean of their ages.

Mean is an arithmetic average of all the values. A problem with this statistic is that extreme values often affect this value. Extreme values create distortion and standard deviation from the square root of the variance, if the value is not extreme, it implies that the data is close to its mean, and predictors tend to be more accurate (Sham, 2008).

Kurtosis characterises the relative peakedness or flatness of distribution compared to a normal distribution. Skewness, on the other hand, measures the lack of symmetry. Abnormal skewed and peaked distributions may be signs of trouble and those problems are likely to arise when analysing the data. Normal distribution is assumed for most of the statistical techniques used in this study. The Kruskal-Wallis test does not assume normal distribution. It does, however, assume the same shape of distribution for the different sub groups.

Inferential statistics

Correlation coefficient between the predictor variables and criterion was calculated to determine the nature and the magnitude of relations.

The Kruskal-Wallis test is the non-parametric substitute to a one-way between-groups analysis of variance. It allows the researcher to compare the scores on some continuous variable for three or more groups. For this study it was important to see if the different tests discriminated between different groups of students, and thus have a predictive value.

The Kruskal-Wallis can be done on categorical data and for that reason the Kruskal-Wallis was done for the ELSA. Categorical data can't be used for correlation analysis. The Kruskal-Wallis analysis was also performed for LPCAT and the Mathematical literacy test, which helped with identifying the discrimination value of each predictor. Normal distribution is not assumed for the Kruskal-Wallis, although not having the same shape of distribution might have a negative effect on the results. The sample size for the Kruskal-Wallis should be as equal as possible, but some variation is allowed.

Regression analysis is a statistical technique used for the investigation of relationships between two or more quantitative variables (Sykes, 2003). Regression analysis was used in this study to understand the statistical dependence of one predictor on another. Regression analysis was done in this study to understand how the different predictors contribute to the prediction of academic success as well as to understand the influence of race as a moderator.

RESULTS

Descriptive statistics

Variable	N	Mean	Std Dev	Kurtosis	Skewness
LPCAT	324	64.462	3.941	-0.205	0.191
Mathematical proficiency test	283	18.749	3.651	0.108	0.051
Academic Year 1	329	66.316	9.938	-0.550	0.154
Academic Year 2	229	62.330	9.596	0.110	0.444
Academic Year 3	125	62.272	9.965	0.838	0.201
Academic Year 4	36	65.274	9.544	-0.119	0.303

Table 3 Descriptive statistics for predictors and criterion measures

The descriptive statistics for the sample is as indicated in Table 3. There is a difference in the sample sizes for the different predictors due to the sampling method. This sample was gathered from 2005 – 2008. All students start off in Grade 12 doing the LPCAT, Mathematics proficiency test and ELSA test. The differences in these sample sizes are due to missing data. Students are in different academic years resulting in the different sample sizes for Year 1 to Year 4.

The data set is not significantly skew, which indicates the data symmetry. There are, however, more values with kurtosis that might be questionable, and that might have an influence on the overall analysis of the study. Although caution needs to be taken around this, it doesn't deviate observably from the normal distribution.

Inferential statistics

Pearson Correlation Coefficients for LCAT and Mathematics proficiency test

The Mathematic scores at first year level for the different Universities were standardised with a mean of zero (0) and a standard deviation of one (1). Criterion values were standardised to statistically control the differences in mean and score variability between universities. The standard acceptable level of significance used to validate a claim of a statistically significant effect is 0.05. An alpha level of 0.05 was used for all statistical tests in this study.

	Academic year 1		
	R	**p-value**	**N**
LPCAT	0.259	<.0001	324
Mathematical proficiency test	0.488	<.0001	283
	Academic year 2		
	R	**p-value**	**N**
LPCAT	0.244	0.0002	225
Mathematical proficiency test	0.330	<.0001	184
	Academic year 3		
	R	**p-value**	**N**
LPCAT	0.207	0.0211	124
Mathematical proficiency test	0.350	0.0010	85
	Academic year 4		
	R	**p-value**	**N**
LPCAT	-0.110	0.5223	36
Mathematical proficiency test	0.395	0.0510	25

Table 4 Correlations of predictor variables with average results over all year groups

Correlation coefficients were calculated between the Mathematical proficiency test and the LPCAT. Table 4 highlights the correlations between the Mathematical proficiency test and LPCAT with the different academic years.

LPCAT (r[324] = 0.259; p < 0.0001) and Mathematical proficiency (r[283] = 0.488; p<0.001) correlated statistically significantly positively with academic performance at first year level. At second year level a positive statistically significant correlation can be reported for LPCAT (r[225] = 0.244, p = 0.0002) and mathematical proficiency (r[184] = 0. 330, p <0.0001).

There is no statistically significant correlation of third and fourth year level for LPCAT. A statistically significantly positive correlation was obtained between mathematical proficiency (r = 350, p = 0.0010) and academic performance at third year level. At fourth year level a significantly positive correlation was obtained between mathematical proficiency (r = 0.395, p = 0.0510) and academic performance.

Range restriction due to pre-selection occurred in this study, the correlation coefficient might be an underestimate of the correlation in the population. For that reason the estimated corrected correlation coefficients were also evaluated. The estimated corrected correlation for the mathematics proficiency test is significant for the first three years of studies. At first year level an estimated positive corrected correlation of (r = 0.691) can be reported, at second year leve the estimated positive corrected correlation is (r =0.442). At third year level (r =0.345) can be reported for the estimated corrected correlation.

The estimated corrected correlation for the LPCAT does not show the same relationship as for the mathematics proficiency test. At first year level an estimated positive corrected correlation of (r = 0.304) can be reported, at second year level the estimated positive corrected correlation is (r =0.288). At third year level (r =0.253) can be reported for the estimated corrected correlation.

Mathematics at first year level			
	R	**p-value**	**n**
Mathematical proficiency test	0.443	<.0001	276

Table 5 Correlation of the mathematical proficiency test with Mathematics results at first year level

Part of the engineering syllabus across all South African Universities is a mathematics subject. This subject is only at first year level. The score for that mathematics subject was standardised across all Universities and correlated with the mathematical proficiency test. A statistically significant positive correlation (r[276] = 0.443; $p < 0.0001$) was obtained when this analysis was done.

Kruskal-Wallis for the ELSA results

	ELSA LITERACY LEVELS														
	Grade 7-9			Grade 10			Grade 11			Grade 12			Grade 12+		
	Mean	N	Std	Mean	n	Std	Mean	n	Std	Mean	n	Std	Mean	n	Std
Academic Year 1	62.361	31	9.211	61.781	33	9.424	64.708	61	9.240	67.788	84	9.701	69.596	69	10.077
Academic Year 2	60.255	25	8.579	60.031	22	10.102	60.448	40	8.759	63.545	49	10.182	64.387	45	9.478
Academic Year 3	57.438	13	8.570	58.883	11	8.220	60.421	18	8.818	63.611	21	10.694	63.239	18	12.962
Academic Year 4	54.913	3	4.170	63.653	4	8.623	65.838	6	12.373	66.544	8	10.774	64.697	3	6.553

Table 6a Relationship according to the Kruskal-Wallis between the ELSA Literacy levels and average academic results across all levels

	ELSA LITERACY LEVELS		
	Kruskal-Walis		
	p-value	Chi-Square	Df
Academic Year 1	0.0002	22.54	4
Academic Year 2	0.0674	8.76	4
Academic Year 3	0.2324	5.58	4
Academic Year 4	0.5659	2.95	4

Table 6b Relationship according to the Kruskal-Wallis between the ELSA Literacy levels and average academic results across all levels

The results obtained by the ELSA are reported as grade levels. For the purpose of analysing these results, it was classified in five different groups. Namely, Grade 7-9, Grade 10, Grade 11, Grade 12 and Grade 12+.

The Kruskal-Wallis Test revealed a statistically significant difference in the different groupings of the ELSA literacy levels and the academic performance of the students in the different years of study. For Academic Year 1 (χ^2 (4, n = 278) = 22.54, p = 0.0002). This implies a significant relationship on the 1% level.

No statistically significant difference was recorded for year 2, year 3 and year 4.

Academic year 1		
Grade Group 1*	**Grade Group 2***	**Effect size (*d*)**
Grade 7 -9	Grade 12+	0.718
Grade 10	Grade 12	0.620
Grade 10	Grade 12+	0.776

Table 7 Effect size of ELSA literacy levels with academic average results at first year level

*These groups differ at p<0.5 according to Kruskal-Wallis

To interpret the practical significant strength of the different effect sizes, the guidelines as proposed by Cohen (1988) were used. The grade groups as indicated in table 7 differ significantly on the 5% level according to the Kruskal-Wallis analysis. Students who have scored at a Grade 7 – 10 literacy level with the ELSA, differ at a practical significant level in respect of academic performance from those whose literacy level is Grade 12 or higher. A practical significance can be reported due to medium effect sizes, all values are above *d* >

0.6. This indicates that the ELSA does discriminate at a moderate level between these different groups.

Kruskal-Wallis for LPCAT and Mathematical proficiency

	Academic Year 1											
	Average 0-49%			**Average 50 – 60%**			**Average 61-74%**			**Average 75+%**		
	Mean	**SD**	**N**	**Mean**	**SD**	**n**	**Mean**	**SD**	**N**	**Mean**	**SD**	**n**
LPCAT	62.538	4.274	13	63.484	3.981	91	64.527	3.678	148	65.917	3.928	72
Mathematical proficiency test	15.692	2.869	13	17.024	3.322	82	19.000	2.939	123	21.062	3.937	65
	Academic Year 2											
LPCAT	62.556	3.399	18	64.223	3.875	94	65.133	3.863	90	66.913	4.078	23
Mathematical proficiency test	18.294	4.012	17	18.244	3.446	78	19.070	2.870	71	22.278	3.159	18
	Academic Year 3											
LPCAT	65.071	3.452	14	63.282	3.448	39	65.000	4.042	60	66.455	4.034	11
Mathematical proficiency test	17.727	2.240	11	17.414	3.561	29	19.368	3.716	38	22.429	4.353	7
	Academic Year 4											
LPCAT	-	-	-	65.538	2.665	13	63.059	4.548	17	64.333	5.610	6
Mathematical proficiency test	-	-	-	17.400	2.413	10	18.364	4.433	11	22.250	3.304	4

Table 8a Relationship according to the Kruskal-Wallis between LPCAT, Mathematical proficiency and average academic results across all levels.

	Academic Year 1		
	Kruskal-Wallis		
	P-value	**Chi-Square**	**Df**
LPCAT	0.0006	17.48	3
Mathematical proficiency test	0.0000	53.38	3
	Academic Year 2		
LPCAT	0.0028	14.07	3
Mathematical proficiency test	0.0006	17.48	3
	Academic Year 3		
LPCAT	0.0777	6.83	3
Mathematical proficiency test	0.0121	10.93	3
	Academic Year 4		
LPCAT	0.1364	3.98	2
Mathematical proficiency test	0.0752	5.18	2

Table 8b Relationship according to the Kruskal-Wallis between LPCAT, Mathematical proficiency and average academic results across all levels.

The average results obtained at tertiary level were divided into 4 different groups for the purpose of this analysis. Group 1 consists of students who have obtained 0 – 49 percent average in respect of academic performance, Group 2 consists of students who have obtained 50 – 60 percent average. Group 3 consists of students who have obtained 61 – 74 percent average and Group 4 consists of students who have obtained 75 percent and more on average.

The Kruskal-Wallis was used to establish the relationship between the LPCAT and the mathematical proficiency test with the academic performance of students in the different years of study. The χ^2 (3, n = 324) = 17.48, p = 0.0006 for the average in year one (1) implies a significant relationship on the 5% level between LPCAT and academic performance. A p = 0.003, χ^2 (3, n = 225) = 14.07 at second (2nd) year level between average academic results and LPCAT implies a significant relationship on the 5% level. There is no significant relationship between LPCAT and academic performance at third or fourth year level. These results confirm the results obtained from the correlation analysis.

Academic year1		
Average Group 1*	**Average Group 2***	**Effect size**
0 – 49%	75+%	0.578
50 – 60%	75+%	0.613
Academic year2		
0 – 49%	75+%	1.066
50 – 60%	75+%	0.659

Table 9 Effect size of LPCAT with average academic results at first and second year level

*These groups differ at p<0.5 according to Kruskal-Wallis

The average groups as indicated in table 9 differ significantly on the 5% level according to the Kruskal-Wallis analysis. At first year level, students who have scored 0 – 49 on the LPCAT, differ with practical significance (*d* **=** 0.578) from those who have scored more than 75. The same goes for students scoring 50 – 60 on the LPCAT. They differ with practical significance (*d* **=** 0.613) from those who have scored more than 75. At second year level students who have scored 0 – 49 differ with practical significance from those who have scored 75 and above, with an effect size of above *d* > 1.066. A practical significance difference (*d* **=** 0.659) can also be reported for students who have scored 50 – 60 against those who have scored 75 and above at second year level. Although the overall correlation coefficients were low, the LPCAT appears to have discrimination value, with moderate to high effect size, between low and high scoring individuals. Thus indicating that the LPCAT does discriminate between the different groups, but not as well as the mathematics test.

The mathematical proficiency test and the averages academic results at the different year levels were all statistically significantly different. The p = 0.000 χ^2 (3, n = 271) = 53.83 for the average academic results at first year level (year 1) implies a relationship on the 1% level with the mathematical proficiency test. A p = 0.0006 χ^2 (3, n = 184) = 17.58 at second (2^{nd}) year level between the average academic results and the mathematical proficiency test implies a significant relationship. There is also a significant relationship at third year level (3) (p = 0.0121) χ^2 (3, n = 124) = 6.83 on the 1% level.

There is not a significant relationship between the mathematical proficiency test and the average academic results at fourth year level.

Academic year 1		
Average Group 1*	**Average Group 2***	**Effect size**
0 – 49%	61 – 74%	1.126
0 – 49%	75+%	1.366
50 – 60%	61 – 74%	0.596
50 – 60%	75+%	1.028
61 – 74%	75+%	0.524
Academic year 2		
0 – 49%	75+%	0.995
50 – 60%	75+%	1.171
61 – 74%	75+%	1.016
Academic year 3		
50 – 60%	75+%	1.154

Table 10 Effect size of the Mathematical proficiency test with reference to average academic results at first, second and third year level

*These groups differ at p<0.5 according to Kruskal-Wallis

The Kruskal-Wallis results are presented in table 10. The analysis indicates a significant difference on the 5% level between the different groups. According to the effect size, which varies from d = 0.596 to d = 1.366, practical significances are clear for most of the combinations. Thus indicating that the Mathematical proficiency test discriminates very well between the different groups in respect of academic performance.

Regression analysis on Mathematical proficiency test and LPCAT

Academic year 1					
Variable	**DF**	β	**Standard Error**	**t value**	**p value**
Step 1					
Intercept	1	32.190	8.611	3.74	0.0002
LPCAT	1	0.154	0.143	1.08	0.2810
Mathematical proficiency test	1	1.287	0.153	8.44	<0.0001
R^2 = 0.246, F(2, 276) = 44.95, p = 0.0001					
Step 2					
Intercept	1	41.013	2.729		<0.0001
Mathematical proficiency test	1	1.345	0.142		<0.0001
R^2 = 0.243, F(1,277) = 88.67, p < 0.0001					

Academic year 2					
Variable	**DF**	β	**Standard Error**	**t value**	**p value**
Step 1					
Intercept	1	36.459	10.766	3.39	0.0009
LPCAT	1	0.148	0.180	0.82	0.4137
Mathematical proficiency test	1	0.848	0.207	4.10	<0.0001
R^2 = 0.117, F(2, 178) = 11.83, p < 0.0001					
Step 2					
Intercept	1	44.75	3.670		<0.0001
Mathematical proficiency test	1	0.914	0.190		<0.0001
R^2 = 0.114, F(1, 179) = 23.023, p < 0.0001					

Table 11 Regression analysis results indicating the relationship between academic performance at first and second year level with the Mathematical proficiency test and LPCAT as predictors.

The final step in the analysis of the data was to conduct a stepwise multiple regression analysis to predict the academic performance at first and second year level. The mathematical proficiency test and LPCAT were treated as independent variables and academic performance at first and second year level as the dependent variable. The results of regression analysis that was performed to determine the relationship between Mathematical proficiency test and LPCAT and the academic performance at first and second year level, is illustrated in Table 11.

According to Table 11, LPCAT does not provide a significant improvement on the regression model when used in combination with the predictor mathematical proficiency. (LPCAT on its own has a significant prediction value, but not over and above the mathematical proficiency test). In step 1, Mathematical proficiency and LPCAT explained 24.6 % variance in first year academic performance, R^2 = 0.246, F(2, 276) = 44.95, p = 0.0001. In step 2 of the regression analysis, the mathematical proficiency test significantly predicted first year academic performance β = 1.287, t(280) = 8.44, p < 0.0001. Mathematical proficiency alone explained a significant proportion of variance in first year academic performance, R^2 = 0.243, F(1,277) = 88.67, p < 0.0001 .

In step 1, Mathematical proficiency and LPCAT explained 11.7 % variance in second year academic performance, R^2 = 0.117, F(2, 178) = 11.83, p < 0.0001. In step 2 of the regression analysis, the mathematical proficiency test significantly predicted first year academic performance β = 0.848, t(181) = 4.10, p < 0.0001. Mathematical proficiency alone explained a significant proportion of variance in second year academic performance, R^2 = 0.114, F(1,179) = 13.023, p < 0.0001 .

Descriptive statistics for ethnic groups in study

Ethnic group	**N Obs**	**Variable**	**N**	**Mean**	**Std Dev**	**Kurtosis**	**Skewness**
Black	73	Academic Year 1	73	61.162	8.390	-0.003	0.407
		Academic Year 2	53	59.362	8.115	0.461	0.530
		LPCAT	71	62.000	3.723	1.658	1.000
		Mathematical proficiency test	60	16.85	3.677	-0.484	-0.241
Indian	84	Academic Year 1	84	64.892	9.956	0.471	0.554
		Academic Year 2	54	59.297	8.892	0.427	0.751
		LPCAT	82	63.866	3.899	0.899	0.230
		Mathematical proficiency test	71	18.338	3.779	0.300	0.607
White	159	Academic Year 1	159	69.113	9.554	-0.700	-0.188
		Academic Year 2	114	64.972	9.499	-0.036	0.478
		LPCAT	159	65.836	3.529	-0.767	0.149
		Mathematical proficiency test	139	19.770	3.300	0.113	0.088

Table 12 Descriptive statistics for ethnic groups

Table 12 indicates the descriptive statistics for the different ethnic groups in this study. Overall the sample sizes for students in their first academic are higher than in their second year. The ethnic group white is best represented in this study. There is a very distinct difference in the mean scores of the different ethnic groups. A notable positive skewness as well as a positive kurtosis can be reported for the LPCAT results for the ethnic group black.

Inferential statistics on ethnic groups

The enter method Regression analysis

Academic year 1					
Variable	**DF**	**Unstandardised slope coefficients (β)**	**Standard Error**	**t value**	**p value**
Intercept	1	41.748	4.411	9.46	<0.0001
Mathematical proficiency test	1	1.373	0.220	6.24	<0.0001
Race1 [0]	1	10.675	6.825	1.56	0.1190
Race2[1]	1	-2.112	6.706	-0.31	0.7530
Mathematical proficiency test X race1[2]	1	-0.884	0.374	-2.36	0.0188
Mathematical proficiency test X race2[3]	1	0.005	0.348	0.01	0.9886

Table 13 Regression analysis of ethnic groups with dummy variables.

[0] Category variable Race1; Black =1; White = 0;

[1] Category variable Race2; Indian=1; White = 0;

[2] Mathematical proficiency test & race1 = Interaction Race1 and Mathematical proficiency test results;

[3] Mathematical proficiency test & race2 = students with a score for the mathematical proficiency test and who are Indian

The mathematical proficiency test results for the Black students don't significantly predict first year academic performance. When the analysis of the variance was done for the different ethnic groups at first year level, the results for the black students showed (R^2 = 0.0431; p = 0.1113) no significant contribution.

The mathematical proficiency test results for the Indian student significantly predicted first year academic performance $\beta = 1.378$, $t(69) = 4.96$, $p < 0.0001$. Mathematical proficiency also explained a significant proportion of variance in their first year academic performance, $R^2 = 0.2631$, $F(1,69) = 24.64$, $p < 0.0001$.

The mathematical proficiency test results for the White students significantly predicted first year academic performance $\beta = 1.372$, $t(137) = 6.34$, $p < 0.0001$. Mathematical proficiency also explained a significant proportion of variance in their first year academic performance, $R^2 = 0.2266$, $F(1,137) = 40.14$, $p < 0.0001$.

Dummy variables were used to identify categories in the regression analysis (Berenson, Levine & Goldstein, 1983). Race1 is the first year scores of the black group (race1=1); Race2 is the first year scores for the Indian group (race2=1). The white group was used as a reference group (race1=0 & race2=0). Mathematical proficiency test X race1 resembles the interaction between the two variables with a score for the mathematics proficiency test and who are black (Mathematical proficiency test & race1 =1). Mathematical proficiency test X race2 resembles the interaction between the two variables with a score for the mathematical proficiency test and who are Indian (Mathematical proficiency test & race2 =1). The white group was again used as the reference group (Mathematical proficiency test & race1=0 & Mathematical proficiency test & race2 =0).

A regression analysis was done to determine the relationship at first year level. When the unstandardised slope coefficients (β) for the dummy variables are interpreted as per table 13, the following can be reported at first year level. Due to the fact that both variables for the black group (race1 & Mathematical proficiency test X race1) differ significantly in this model ($p < 0.05$), the conclusion can be made that the regression line for race1 = 1 differs significantly from the regression line for race1 = 0 and race2 = 0. This means that the slope differs significantly for the black group when compared with the reference group (white). The intercept for the black group does not differ from the reference group (white).

For the Indian group, due to the fact that neither variables (race2 & Mathematical proficiency test & race2) differs significantly in this model ($p > 0.05$), the conclusion can be made that in race2=1 the regression line does not differ significantly from the regression line for race1=0 and race2=0. Neither the slope nor intercept differs significantly from the reference group.

DISCUSSIONS

This study was aimed at investigating the criterion related validity of cognitive and academic literacy tests as predictors of academic performance for students in the field of engineering. This research contributes to the educational literature by demonstrating the importance and effectiveness of additional selection measures as entry requirements into tertiary education.

The initial Pearson-correlation coefficient indicates statistical significant relationships for the Mathematical proficiency test and the LPCAT with the academic average results at first year and second year level. Furthermore, the Mathematical proficiency test also indicates statistical significant relationships with academic averages at all levels of tertiary education except at fourth year level. Statistically significant relationship was found between the Mathematical proficiency test and results of 1st year mathematics (Wisk). The results gained from the Kruskal-Wallis done on the relationship between LPCAT and mathematical proficiency test with the average results across all years of studies show similar patterns. When LPCAT is used in combination with Mathematical proficiency tests in the regression model, the LPCAT does not significantly increase the explained variance on the criterion variable or predictive value.

A practical significance can be reported for the ELSA, which indicates that the ELSA discriminates between the different levels of the ELSA. It is thus evident that the ELSA does have predictive characteristics regarding the performance of engineering students at first year level when their first year results are taken into consideration.

The effect sizes indicate practical significance for all the predictors. The mathematical proficiency test, however, has the strongest discrimination characteristics. LPCAT and ELSA appear to discriminate at a practical significant level when specifically comparing the test scores of the highest and lowest academic performers.

It is evident from the results of this study that the best predictors of academic performance at tertiary level are tests that measure the ability of Mathematical reasoning. Previous research by Eiselen (2007) indicates that a basic mathematical skill test is the best predictor for success at tertiary level in general. The results also indicate that learning potential tests (LPCAT) as well as a literacy test (ELSA) make significant contributions in the prediction of academic success at tertiary level.

The regression analysis done on the different ethnic groups revealed that the mathematical proficiency test contributed significantly to the prediction of the first year results for the Indian and White population, but not for the Black population. This can be due to test bias and/or cultural influence. Another reason for this can be due to criterion contamination. The results of the students are obtained from different tertiary institutions, so there is a range of contaminating factors that might have an influence. Cascio (2005) indicates that criterion contamination occurs when the operational or actual criterion includes discrepancy that is not related to the definitive criterion. More research needs to be done to determine the course of this occurrence.

One of the limitations for this study is the pre-selection of the sample. The students were firstly selected on grounds that they have met minimum criteria to qualify to attend a tertiary institution. Secondly, only students coming out on top with the assessments were monitored. The sample is thus of students who were all very close to each other in terms of academic achievements. Analysis was limited to the average of academic results across the different tertiary levels, due to different curricula and different subjects at different tertiary institutions it would have meant that the analysis would have been done on relatively small samples and for that reason it was not possible to analyse more subgroups.

Due to the facts as mentioned above, range restriction occurred. Range restriction occurs in the predictor when only the students who have survived the initial assessments are considered. The criterion data is unavailable for low scorers who did not get a bursary. This is known as direct range restriction (Cascio, 2005).

Careful consideration should be given when interpreting correlation coefficients when it comes from only a small subsection of possible range of scores. Correlation coefficients from studies using a restricted range of cases are often different from studies where the full range of possible scores are sampled (Pallant, 2007). Due to the range restriction in the sample and thus of the test scores, the correlation obtained is normally an underestimate of the correlation in the population (Wiber & Sundström, 2009).

Suggestions for further research highlight the need to incorporate a broader sample with less range restriction as well as a sample that has the same criterion measures. By reducing the criterion contamination, more accurate statistics can be reported.

To conclude, the need for proficiency tests with the purpose of selection can currently not be overemphasised in South Africa. Given the expense to the student, the tertiary institution and the company supporting the students, in terms of finance, time and effort, a reasonable measure should be in place for the selection of students (Scoltz & Allen-ile, 2007).

Overall, it can be concluded that the assessment battery used in this study does have predictive validity in terms of predicting the academic performance of engineering students at tertiary level. The results of this study indicate that the Mathematics proficiency tests have the best predictive characteristics. This supports the notion that best predictors of future achievement in a domain are current achievement in that domain and the ability to reason in the symbol system(s) used to communicate new knowledge in the domain (Lohman, 2003).

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