

**THE VALIDITY OF THE SITUATION SPECIFIC EVALUATION EXPERT (SPEEX)  
FOR PREDICTING ACADEMIC SUCCESS OF FIRST YEAR MECHANICAL  
ENGINEERING STUDENTS AT THE VAAL TRIANGLE TECHNIKON**

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Dedicated to my husband John Malatjie and child Tshepo Malatjie for being the pillar of my strength and for their continuous support during the times when the going got tough.

And

to the loving memory of my mum Maggie Jane Kubayi for being the inspiration for everything I do.

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## **ABSTRACT**

**Subject:** The validity of the Situation Specific Evaluation Expert (SPEEX) for predicting academic success of first year Mechanical Engineering students.

**Key terms:** academic success, Situation Specific Evaluation Expert (SPEEX), validity, prediction studies.

Institutions of higher learning are currently faced with the crisis of finding appropriate criteria for undergraduate admission. This concern has been sparked by the fact that matriculation grades are no longer seen as an accurate reflection of students' academic potential. As tertiary education is becoming more expensive, it is therefore becoming more and more important to select only students who have a realistic chance of being successful in their studies.

The main aim of this study is to validate the Situation Specific Evaluation Expert (SPEEX) as a predictor of academic success of first year students of Mechanical Engineering at the Vaal Triangle Technikon.

The design used in this study is a non-experimental correlational design. This design was selected because the investigation of this study is aimed at determining the presence or absence of the relationship between the independent and dependent variables without specific reference to causality.

The sample of this study consisted of a total of 140 mechanical engineering student at the Vaal Triangle Technikon. This sample was the total number of students from the Mechanical Engineering department who enrolled for mechanical engineering courses for the year 2000. The sample consisted of 94% males and females 6% females.

Subject matter experts from industry as well as those involved in the training of

Mechanical Engineering at the Vaal Triangle Technikon selected competencies, which were hypothesised to be indicative of a potentially successful student. Based on the selected competencies the assessment battery was compiled with the selected indices being considered as predictor variables. A multiple regression analysis was performed on data in order to establish the predictive validity of the assessment battery.

SPEEX 2502 (Language proficiency) consistently showed a positive correlation on the prediction of academic success.

## **OPSOMMING**

**Onderwerp:** Die validering van die Situasi Spesifieke Evaluerings Kundige (SPEEX) vir die voorspelling van eerstejaar Meganiese Ingenieurswese studente.

Hoër Onderwys instansies ondervind tans die krisis om geskikte kriteria te vind vir toelatingsdoeleindes van ongegradueerdes. Dit is as gevolg van die feit dat matriekuitslae nie meer gesien word as 'n ware refleksie van studente se potensiaal nie. Weens die feit dat tersiêre opleiding al duurder word, is dit daarom belangrik om slegs die studente te selekteer wat 'n realistiese kans vir sukses in hulle studies het.

Die hoofdoel van die validering van die (SPEEX) was om toe te sien dat meer akademiese sukses bereik word deur eerstejaar Meganiese Ingenieurswese studente by die Vaaldriehoek Technikon.

Die ontwerp wat gebruik is nie-eksperimenteel. Dit is slegs 'n ondersoek van die studie van afwesighede en verwantskappe tussen die afhanklike en onafhanklike te bepaal.

Die groep wat gebruik is bestaan uit 140 Meganiese Ingenieursstudente by die Vaaldriehoek Technikon. Dit was die totale aantal Meganiese Ingenieursstudente wat deel was van die 2000 Meganiese Ingenieurskursus, en bestaan uit 94% mans en 6% dames.

Vakspesialiste uit die industrie en persone gemoeid met die opleiding van die Meganiese Ingenieursstudente by die Vaaldriehoek Technikon het vaardighede uitgewys wat gemik was op die potensiaal van die student. Met dit in gedagte en die aflegging van die toetsbattery is daar sekere idees genereer wat waardevol was. 'n Analise is opgestel om die waarde van die data van die toetsbattery te bepaal.

Sekere resultate van die SPEEX bewys dat 'n konstante positiewe korrelasie bestaan tussen taalbevoegdheid en akademiese sukses.

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## **CHAPTER 1**

### **INTRODUCTION**

This mini-dissertation focuses on the validity of the Situation Specific Evaluation Expert (SPEEX) for predicting academic success of first-year Mechanical Engineering students.

Chapter 1 contains the problem statement, research objectives, paradigm perspective and research methodology employed. In addition, the division of chapters in this mini-dissertation is presented.

#### **1.1 PROBLEM STATEMENT**

In South Africa, the past decade's political changes and the recent publications of documents such as the "Size and Shape" of tertiary institutions (Mboyane, 2000) have urged tertiary institutions to re-evaluate their policies and methods regarding student selection and access. As tertiary institutions receive the bulk of their government subsidies on the number of successful students, the increasing financial burden of Higher Education institutions implies that institutions will no longer be able to bear the burden of unsatisfactory study progress by students (Stumph, 1997). Pienaar (1991) states that tertiary education is cost-intensive and therefore it will become more and more important to select only students who have a realistic chance of being successful for higher education.

Traditionally, scholastic achievements were used as selection criteria to gain access to South Africa's tertiary institutions. Currently matriculation results cannot be seen as a true reflection of students academic potential due to the great disparity between resources and learning opportunities at different schools (Griesel, 1991). At the same time, however, it would be irresponsible of academic institutions to admit students who have a high probability of failing due to

psychological and financial implications (Nunns & Ortlepp, 1994). Research in South Africa and other countries has indicated that matriculation results remain the single best predictor of success at tertiary level. However, it was found that matriculation results of matriculants from the previous Department of Education and Training and equivalent school systems are an inaccurate reflection of students' academic ability or potential for success at tertiary level (Kotzé, Nel & Van der Merwe, 1996).

Van Aswegen (1997) supports the above-mentioned authors by stating that implications of the inequalities in the education system are clearly demonstrated by the patterns of access to higher education. Universities and technikons are currently faced with the crisis of finding appropriate criteria for undergraduate admission of previously disadvantaged black students as the difference in the allocation of resources between black and white schools influences the credibility of grades obtained as an accurate reflection of students' academic potential (Van Aswegen, 1997).

From the above, it is clear that there is a dire need for a valid, reliable and fair instrument to assess the ability of prospective students in order to see whether they have the potential to be successful in their studies. Institutions of higher learning in South Africa have a responsibility to provide society with well-trained and skilled personnel while catering for a more diverse intake in terms of student access to tertiary institutions. In the recent recommendations made by the Council on Higher Education (CHE), tertiary institutions were urged to position themselves as niche providers so they can meet national needs and compete with each other (Mboyane, 2000). Since most tertiary institutions are dependent on government subsidies for financial support, they have to make sure that the students they enrol are successful academically in order to maintain the subsidies, attract donors as well as to demonstrate the institution's capability to produce competent graduates.

The concept of academic success has frequently been used in psychological research. However, few investigators have defined this concept in their reports. While several reports mention certain criteria for academic success, even these criteria differ somewhat from one investigation to another (Malekele, 1994).

Nunns and Ortlepp (1994) define academic success as passing of an academic year. Raijmakers (1993) provides a broader definition of academic success as:

- Obtaining a pass mark in a subject and a final qualification, degree, diploma or certificate;
- Being able to transfer skills learned in a theoretical context to real life situations, like problem-solving and thinking skills; and
- The ability to think and reason.

Thorndike, Cunningham, Thorndike and Hagen (1991) believe that if something such as academic success exists, it exists to some degree and can therefore be measured. Most tertiary education institutions are searching for ways of selecting students that will reflect accuracy as well as fairness. Many researchers have developed admission tests that correlate strongly with academic performance, but are independent of socio-economic factors and past schooling (De Villiers, 1999). The use of psychometric or admission test results in addition to school grades may offer the possibility of achieving a better and fairer distribution of educational opportunities. The provisions of the Employment Equity Act (Employment Equity Act No.55 of 1998) have recently endorsed fairness in assessment. It is, therefore, important to ensure compliance with this Act when conducting assessment of any kind.

The Situation Specific Evaluation Expert (SPEEX) is intended to evaluate certain specific aspects of an individual's cognitive (intellectual) abilities. The aim with the SPEEX is to provide instruments suitable for the establishment of potential in areas of human performance and success. A number of separate psychometric indices were developed for the assessment of potential in areas such as

conceptualisation, observance, insight, perception, linguistic proficiency, reading comprehension, assembling, comparison and advanced calculations (Erasmus & Minnaar, 1997).

The situation specific approach of the SPEEX (i.e. having different dimensions that assess specific abilities) to standardisation, validation and the establishment of reliability has rendered vital foundations of assessment in the South African workplace at large, by the new legislation in general and the Equity Act in particular (Erasmus & Minnaar, 1997). The SPEEX is in a position to claim that it comprises the most up to date standardised instruments. This is because of its situation-specific compliance, which requires a scientific validation that provides results that are appropriate for the intended purpose.

Engineering students at a technikon were selected for the study. The Faculty of Engineering where this study was conducted is concerned about the throughput rates of its students, with most students failing more than half of their courses especially in the first year. The question of throughput rates in tertiary institutions also seems to be a national concern. According to Stumph (1997), the official average pass rate for students enrolled at South African technikons for three-year diplomas was 15% for historically white institutions and 9% for historically black institutions in 1990. Official records for Technikon Pretoria show that 35% of the students registered as first year students in 1996 dropped out of their courses by the beginning of 1997. This figure does not take the 34% that failed more than half their subjects into account (Technikon Pretoria: Strategic Information and Planning, 1998). The Faculty of Engineering where this study was conducted is cooperative with regard to the use of psychometric assessment for admitting first-year students. As a result, data were readily available to conduct the study.

Different researchers (Rochford, Fairall, Irving & Hurly (1989); Rochford & Archer, (1990) investigated the academic performance of 1600 science and

engineering first-semester students and confirmed the trend towards significant levels of under-achievement by cognitively weak students. They concluded that there was a significant relationship between student scores on tests of cognitive ability and their performance in examinations.

Rochford and Sass (1988) also reported that students' cognitive ability test scores were significant predictors of final academic performances in engineering courses as well as being valuable diagnostic tools to identify students who would benefit from remedial assistance. They stated that many researchers had recognised the important role that cognitive ability played in learning of a variety of scientific and technological subjects.

A study conducted by Rochford and Archer (1990) on chemistry students at the University of Cape Town (1986-1987) found that science and engineering students with spatial-visualisation handicaps experienced problems in their courses. It seems that tertiary students might fail their academic subjects as a result of cognitive or information-processing deficits. Visual perceptual deficits could also have measurable effects on students' academic achievements. These findings concurred with those of Rochford (1989) who reported that many engineering students were academically handicapped as a result of three-dimensional perceptual learning disabilities.

There are other factors indicated in the literature that may contribute to academic success, but for the purpose of this study, the focus will be on the following factors as dimensions measured by the SPEEX: conceptualisation, observance, insight, perception, linguistic proficiency, reading comprehension, assembling, comparison and advanced calculations.

Based on the exposition of the problem, this study will attempt to answer the following questions:



- How are academic success and its relationship with specific abilities conceptualised in the literature?
- What is the relationship between conceptualisation, observance, insight, perception, linguistic proficiency, reading comprehension, assembling, comparison and advanced calculations as measured by the SPEEX on the one hand and academic success of first year Mechanical Engineering students on the other?
- To what degree can conceptualisation, observance, insight, perception, linguistic proficiency, reading comprehension, assembling, comparison and advanced calculations as measured by the SPEEX predict academic success of first-year Mechanical Engineering students?

## **1.2 RESEARCH OBJECTIVES**

The objectives of this research include both a general and specific objectives.

### **1.2.1 General objective**

With reference to the above formulation of the problem, the general objective of this research is to determine the validity of the Situation Specific Evaluation Expert (SPEEX) as a predictor of academic success of first-year Mechanical Engineering students.

### **1.2.2 Specific objectives**

The specific research objectives are as follows:

- To determine academic success and its relationship with specific abilities as conceptualised in the literature.
- To determine the relationship between conceptualisation, observance, insight, perception, linguistic proficiency, reading comprehension,

assembling, comparison and advanced calculations as measured by SPEEX on the one hand and academic success of first-year Mechanical Engineering students on the other.

- To determine the relationship between Conceptualisation (SPEEX 100) and academic success.
- To determine the relationship between Advanced Calculations (SPEEX 302) and academic success.
- To determine the relationship between Comparison (SPEEX 700) and academic success.
- To determine the relationship between Perception (SPEEX 800) and academic success.
- To determine the relationship between Reading Comprehension (SPEEX 1600) and academic success.

### **1.3 THE PARADIGMATIC PERSPECTIVE OF THE RESEARCH**

The paradigm perspective of this research will focus on academic success from a salutogenic paradigm. The research will therefore include a discussion of constructs related to academic success with regard to the selection of specific indices of the SPEEX, which will be included in the present study. The selected SPEEX indices will be defined according to SPEEX terms (Erasmus, 1999) and discussed with regard to their suitability as predictors of academic success based on known theory related to psychological well-being, sense of coherence and related constructs.

#### **1.3.1 The intellectual climate**

In this study, the disciplinary relationship focuses primarily on Industrial Psychology, which can be defined as the scientific study of human behaviour and psychological conditions in the work-related context and the application of this knowledge to minimise problems that might arise (McCormick & Ilgen, 1981). It

includes organisational variables such as recruitment and placement of personnel, training, motivation of personnel, performance appraisal, the management of morale and weariness and organisational psychology (Plug, Louw, Gouws & Meyer, 1997).

It is postulated by Mouton and Marais (1992) that the intellectual climate of a specific discipline refers to a variety of meta-theoretical values and beliefs held by those practicing within the same discipline. The intellectual climate differs from a discipline in the sense that beliefs in the intellectual climate take on the form of presuppositions.

### **1.3.2 The market of intellectual resources**

The market of intellectual resources refers to the set of convictions that lend epistemic status to scientific assertions, and a distinction can be made between theoretical and methodological beliefs (Mouton & Marais, 1992).

#### **1.3.2.1 Theoretical beliefs**

Mouton and Marais (1992) defined theoretical beliefs as those from which testable statements about social phenomena are made. Theoretical beliefs are therefore descriptive and interpretative explanations pertaining to aspects of human behaviour and as such include all statements forming part of hypotheses, typologies, theoretical definitions, models and theories.

The elements of theoretical beliefs, including theoretical definitions, models and theories, applicable to this research are as follows:

##### **a Theoretical definitions**

The following conceptual descriptions are applicable to this research:

Academic success, validity, prediction studies, SPEEX, salutogenesis. Each will be briefly defined below.

As indicated earlier in this chapter, Raijmakers (1993) provided a broader definition of academic success as firstly, obtaining a pass mark in a subject and a final qualification, degree, diploma or certificate. Secondly, being able to transfer skills learned in theoretical context to real life situations, like problem-solving and thinking skills. Lastly, the ability to think and reason is considered important.

The concept of validity encompasses the following: A psychological test must not only yield constant results in repeated administrations (reliability), but must also measure what it is intended to measure (validity) (Cooper, 1998; Gregory, 1996; Kriel, 1997; Smith, 1996). It is erroneous to talk of test validity as if it were a specific property that a test possesses. A test does not have fixed coefficient of validity, which are applicable for every purpose and for every group of individual for which it might possibly be used. A test has a high or low validity for the specific purpose for which it is used, as well as for the group within which it has to discriminate (Anastasi, 1998; Kriel, 1998; Magnusson, 1967; Smith, 1996). However, tests are not necessarily used for only one specific purpose and therefore different criteria are needed for different test purposes (Smith, 1996). Validity is said to refer to the extent to which a test measures what it is designed or developed to measure (Brown, 1983; Walsh & Betz, 1985, Anastasi & Urbina, 1997; Kline, 1993). A number of theorists add that validity involves the extent to which appropriate and meaningful inferences can be made from test scores and other measurements (Sax, 1980; Brown, 1983; AERA, APA, NCME, 1985; Mehrens & Lehmann, 1991; Gregory, 1996).

In a prediction study, one variable (predictor variable) is used to predict performance on a second variable (criterion variable) and the predictor is usually measured before the criterion variable (McMillan & Schumacher, 1993). A positive correlation means that high values of one variable are associated with

values on a second variable whereas a negative correlation is found when a high value on one variable is associated with a low value on a second variable (McMillan & Schumacher, 1993).

Situation Specific Evaluation Expert (SPEEX) is a registered South African psychological instrument that was developed by Erasmus and Minnaar (1995) as an advanced battery from the Potential Index Batteries (PIB), for the purpose of establishing potential in areas of human performance (McFarlane, 1998). This assessment tool has been highly rated in terms of cultural fairness and is widely used in the industry. The SPEEX consists of a series of culturally fair, computerised, flexible and comprehensive tests, aimed at illiterate, semi-literate and academically advanced individuals alike. The SPEEX's visual scales are language free, thus can be used with all candidates regardless of the language they speak. The SPEEX is divided into two broad categories namely visual tests and pen and paper tests and comprises six separate batteries each aimed at a specific population. Each separate battery is divided into a number of indices (Erasmus & Minnaar, 1995; 1997). The indices are aimed at the screening of potential in various cognitive, emotional and social dimensions (Erasmus & Minnaar, 1997).

The concept of salutogenesis was first introduced in 1979 by Antonovsky (1979; 1987), and means the origins of health. Antonovsky (1987) was fascinated with the question that forms the basis of salutogenesis, namely how people manage stress and survive, stay healthy and even prosper.

## **b Theoretical models and theories**

According to Mouton and Marais (1992), theoretical models are used to classify and suggest relationships between variables, while theories are "...system(s) of interconnected abstractions or ideas that condense and organize knowledge

about the social world" (Neuman, 1997). The following models and theories are used in this study:

Personality theories and models as well as cognitive-behavioural models will each be briefly described below:

Over the last few decades, numerous personality theories have attempted to identify and clarify the aspect of psychological optimal functioning in people, with each author contributing his / her view or conceptualization to this extensive literature. According to the psychoanalytic perspective (Van Eeden, 1996) psychological well-being is conceptualised as an integration of personality aspects, which lead to ego strengths. These ego strengths enable a person to realise his / her potential and to function effectively. Therefore, a person with a healthy personality experiences the self-competence to manage life's demands.

The cognitive-behavioural approach (Van Eeden, 1996), on the other hand, proposes that psychological well-being is equal to optimal, learned cognitive and behavioural skills. These skills are integrated in the personality as constructs and with the aid of these personal cognitive and behavioural patterns life's reality is often successfully mastered (Van Eeden, 1996).

### **1.3.3 Methodological beliefs**

Methodological beliefs are aligned to those beliefs that form part of the intellectual resources (Mouton & Marais, 1992). They further point out that methodological beliefs are those methodological preferences, assumptions and presuppositions about what ought to constitute good research. Included amongst these beliefs are the types of traditions practiced in the philosophy of social science, such as positivism or phenomenology, as well as methodological models such as quantitative or qualitative models.

### **1.4.2 Phase 2: Empirical study**

The following components of the empirical study are designed to assist in achieving the research objectives.

#### **1.4.2.1 Research design**

The research design is classified as a survey design or correlational design (Huysamen, 1993). For the purpose of this study, quantitative research method will be used. The aim of this design is to ascertain whether the scores obtained from the SPEEX indices will influence academic success of the students.

#### **1.4.2.2 Study population**

The study population consists of all first-year Mechanical Engineering students for the year 2000 and 2001 registration periods. All enrolled first-year Mechanical Engineering students serve as the population of the study (N=140).

#### **1.4.2.3 Measuring battery**

The Situation Specific Evaluation Expert (SPEEX) (Erasmus & Minnaar, 1999) is used to determine whether there will be a correlation between academic success and results obtained. As a criterion measure, academic success is used. The parameters for this are that students have to pass half of the courses they register for with at least 50% per course and two of the courses passed must be their major courses. Regarding criteria related to reliability and validity, it has been established that in a first study, multiple regression analysis was performed on 365 cases of managers using the stepwise method to identify the variables contributing most to the predictive validity of the SPEEX (Schaap, 1996). In this particular study, performance appraisal results and percentage salary increases

were used as criterion measures. The inter-correlation between the measures is 0,59.

In a second study performed by Kriel (1997) at Technikon Pretoria, the same procedure was used and the predictive validity of the different SPEEX indices was determined on a sample of 5071 cases. In this study, students' performance on academic tests and examinations were used as criterion measures. The correlation ranged between 0,55-0,82.

#### **1.4.2.4 Data analysis**

The data analysis will be carried out with the help of the SAS-program (SAS Institute, 2000) Cronbach alpha coefficients and inter-item correlation coefficients will be used to assess the reliability and validity of the measuring instrument (Clark & Watson, 1995). Descriptive statistics (e.g. means, standard deviations, range, skewness and kurtosis) and inferential statistics will be used to analyse the data. Pearson and Spearman correlation coefficients will be computed to determine the relationships between variables. Moderated hierarchical regression analyses will be conducted to study the interaction effects between variables.

### **1.5 CHAPTER DIVISION**

This mini-dissertation consists of the following chapters:

Chapter 2: Academic success and its relationship with specific abilities

Chapter 3: Empirical study

Chapter 4: Results and discussion

Chapter 5: Conclusion, limitations and recommendations.



## **1.6 Chapter Summary**

This chapter sought to provide details of the motivation for this research as well as the methodology to be employed. In addition to the problem statement, the objectives of the research, the research method and the paradigmatic context were outlined. Finally, the envisaged chapter arrangement was indicated.

Chapter 2 focuses on academic success and its relationship with specific abilities.

## **CHAPTER 2**

### **ACADEMIC SUCCESS AND ITS RELATIONSHIP WITH SPECIFIC ABILITIES**

In this chapter academic success within tertiary institutions and its relationship with specific abilities (i.e. conceptualisation, observance, insight, perception, linguistic proficiency, reading comprehension, assembling, comparison and advanced calculations) are discussed. A working definition of academic success is also provided. This is followed by a brief overview of the challenges that are related to access to higher education as well as the current perceptions on psychometric testing with regard to admissions. Models of academic success will also be discussed.

#### **2.1 INTRODUCTION**

Schools and universities world-wide are required to fulfil a variety of functions, one of which is to serve as selection and certification agencies and making sure that individuals are suited to, and competent for their social and occupational roles (Malekele, 1994). They contribute to personal development, to giving everybody a fair chance and are supposed to contribute to greater social equality. The lack of consensus regarding priorities to be assigned to these different functions and the changing interpretation of such key concepts as merit, competence and equality, leads to educational systems not being seen as adequately fulfilling many expectations of different social groups (Furth, 1978).

As admission to higher education has been made more accessible, the profile of the student undergoing training has changed drastically. Due to historical inequalities, a large proportion of current students lack certain academic skills necessary to accomplish success in a tertiary environment (Malekele, 1994). This has a definite influence on the validity of predictors and criteria of academic success.

In 1985 the Human Sciences Research Council undertook a research project in respect of the selection of tertiary students (Erasmus, 1999). Course-specific selection was recommended as a suitable selection method. However, the fields of study at universities and more especially technikons impose distinctive requirements for each course of study, making it difficult to do course-specific selection. The emphases that present society places on specialisation and specialised roles complicate matters even more for tertiary institutions (Kotzé, Nel & Van der Merwe, 1996). In order to address this issue, it was stated by Cronbach (1990) that individuals should be allowed to follow different paths in training in order to fulfil these different specialised roles.

In order to understand the importance of accurately selecting and eventually admitting the prospect student into a tertiary institution, the concept of academic success needs to be clarified.

## **2.2 DEFINITION OF ACADEMIC SUCCESS**

The concept of academic success has been used frequently in psychological research; however, few researchers have defined this concept in their reports. While several reports mention certain criteria for academic success, even these criteria differ somewhat from one researcher to another (Malekele, 1994).

Nunns and Ortlepp (1994) define academic success as the passing of an academic year. This definition, however, does not specify exactly the parameters under which a student would be considered having passed an academic year. Rajmakers (1993) provided a broader definition of academic success as, firstly, obtaining a pass mark in a subject and a final qualification, degree, diploma or certificate, and secondly, being able to transfer skills learned in theoretical context to real life situations, like problem-solving and thinking skills and lastly, the ability to think and reason. This definition seems to be a more relevant

definition to the current study due to the fact that it specifies that a student must first obtain a pass mark in a subject, then a final qualification and then be able to apply the knowledge in a practical environment. For the purposes of this study, the parameters for academic success will be that a student has to pass half of the courses they register for with at least 50% per course and two of the courses passed must be their major courses, then they must obtain a final qualification, i.e. a diploma. These parameters are in line with the minimum requirements set by the engineering department of the Technikon for promotion from one semester to another. These parameters are applicable to all engineering students. The fact that a student must be able to transfer skills learned in a theoretical context to real-life situations is outside the scope of this study as the writer would not be able to monitor skills transfer.

Thorndike, Cumminghan and Hagen (1991) believe that if something such as academic success exists, it exists to a certain degree and can therefore be measured. Most tertiary education institutions are actively searching for effective ways of selecting students that will reflect accuracy as well as fairness in terms of academic success. In order to understand the selection method of students into tertiary institutions and the role it plays in academic success, an overview will be given on the current access to higher education specifically in South Africa.

### **2.3 ACCESS TO HIGHER EDUCATION IN SOUTH AFRICA**

The demand for access to higher education has increased dramatically, which in turn has led to an increasing debate about school-leaving examinations and selection for tertiary education (Bradbury & Griesel, 1993). In transforming the higher education system to accommodate the new democratic order in South Africa, access and admission policies has become important issues that needs to be addressed (Griesel, 1991).

Admission policies and in particular, selection procedures are high on the redress agenda of all tertiary institutions. On the one hand, methods of selection are targeted as obstacles to access and on the other, are relied on as means of predicting success and restricting entry only to those students who meet certain criteria (Griesel, 1991). Selection procedures are usually debated with an instrumental context, with the focus largely on technical problems concerning the validity and reliability of the criterion measures (Griesel, 1991). Decisions to use a particular criterion have implications that extend beyond the accuracy or efficiency of a particular selection tool. Although a test may select students who subsequently succeed accurately, it may also reject students whom would have succeeded had they been granted admission (Nzimande, 1995). The standard criterion for higher education has been and remains the matriculation examination, usually based on a conversion that yields a composite score reflecting a student's overall performance (Kriel, 1998).

Prior to the 1980s, little research had been done in South Africa on the school examination system and its predictive value (Nzimande, 1995). There seems to be a difference of opinion as to whether the matriculation examination is primarily a prognostic test to predict future academic success or whether it is an assessment of a standard of general education (Nzimande, 1995). In research done on first-year students at the University of Durban-Westville, Gounden (1977) concluded that the Senior Certificate results are not a good predictor of academic success. A 1958 research report (Education Bureau Report, 1958) suggested that the matriculation examination should be seen as proof of a general level of education and that no scientifically tenable pronouncements could be made regarding university admission (Kotzé, Nel & Van der Merwe, 1996).

From the information presented above, it is clear that the problems of access to higher education have not yet been solved. It is important for researchers to develop innovative measures to assist tertiary institutions with the selection of

students with the potential to be successful. The SPEEX is an assessment tool that tries to address the questions raised due to admission tools and selection methods. Following is information on the psychometric tests used as admission devices in tertiary institutions.

## **2.4 PERCEPTIONS OF PSYCHOMETRIC TESTING AS AN ADMISSION DEVICE IN TERTIARY INSTITUTIONS**

According to Taylor (1987), First World countries such as the United States of America are becoming more and more culturally diverse, ultimately resulting in experiencing problems with admission tests as well. However, problems in South Africa are more intense and psychologists need to devote their attention to address these problems by developing appropriate models and instruments (Kotzé *et al*, 1996; Taylor, 1987). Social and political developments could in future drive psychological testing from the scene if it does not adjust its role (Taylor, 1987).

Criticism is often levelled at psychological instruments and the discriminating effect of instruments on decisions regarding certain groups and individuals (Schaap, 1997). In the South African context, a negative accent is often placed on the cultural differences on validity and the results of measurement and interpretation (Kotzé *et al.*, 1996). The validity of psychometric instruments is of utmost importance since it can be used for prediction purposes when making decisions about individuals. For example, a prospective student can be denied access to tertiary education due (partly or solely) to the results of a psychometric instrument (Schaap, 1996).

The search for alternatives for psychological tests over the past years has caused a debate of its own. A critical issue is whether or not there are alternatives to psychological tests that would be better, fairer or more economical (Murphy & Davidschoffer, 1994). Some critics, however, feel that matriculation

results, together with other methods of admission such as interviews and letters of recommendation would lead to better decisions than using psychological tests such as the Scholastic Aptitude Test (Van Aswegen, 1997). Murphy and Davidshoffer (1994) comment that the matriculation results clearly reflect their definition of a test, i.e. it is based on somewhat systematic observations from several different courses under reasonably standard conditions employing systematic (if not always objective) scoring rules. Both interviews and letters of recommendation fall within the category of behavioural observations (Malekele, 1994). These methods are not based on systematic samples of behaviour, they are characterised by highly subjective scoring rules and also lack standardisation (Malekele, 1994).

It is clear that the methods as mentioned above (matriculation results, interviews and letters of recommendation), are less likely to be valid predictors of future performance than well-designed psychological tests. Although psychological tests have their advantages and disadvantages, like any other assessment instrument, they are currently amongst the most accurate and fair instruments with regard to making important decisions about individuals (Malekele, 1994).

The implications of not testing could also be severe. Communities can be blocked from seeking excellence by eliminating a source of data that could be used to determine an individual's potential to be successful, whether it's in education or any other sphere of life (Griesel, 1991).

Despite all the challenges mentioned above, psychometric testing has been and still continues to be practised by a number of organisations. The use of valid and reliable psychometric devices within an organisational context is also regulated by recent and ongoing developments in South African labour legislation (Code of practice for psychological assessment for the workplace in South Africa, 1998). International Guidelines for Test Use have sparked off a number of initiatives and

debates in South Africa, which are having a positive impact on our assessment practices.

The discrepancy between the understanding of psychometric testing lies in the terms of differentiation and discrimination. In an attempt to find a solution to the difficulties facing psychometric testing in South Africa, the idea of assessing learning potential has gained increasing popularity among politicised academics, unionists and personnel practitioners alike (Van Aswegen, 1997).

The popularity of learning potential in South Africa can be ascribed to its promise of providing a means of fair assessment, despite unequal educational opportunities. The proper course of assessment in the present age is not merely to categorise an individual in terms of current functioning, but also to describe the process by which learning facility and disability proceed in a given individual so that it is possible to prescribe development or treatment if necessary (Van Aswegen, 1997). This has been confirmed by the National Union of Metal Workers (NUMSA, 1992) when it placed emphasis in its policy document of 1992 that tests for learning potential ought to be used. The challenge for tertiary institutions lies in the search for modifiability in domain specific skills-assessment of potential, which will also be good predictors of performance in actual work settings.

Many test developers have toiled toward a changed face of psychometric testing as a means of accommodating the demands placed upon psychometric testing. According to Erasmus (1997), a changed face of psychometric testing implies a transition from testing to assessment. Testing is a process in which the person writing the test can either pass or fail, whereas assessment focuses on potential.

A potential assessment programme with scientifically proven predictive validity was suggested as a measure to ensure that those students with the best chance to pass are admitted to the Vaal Triangle Technikon. For the purposes of this



study, the use of the SPEEX (Erasmus, 1999), as a selection method to predict academic success will be researched.

## **2.5 MODELS OF ACADEMIC SUCCESS**

In order to gain a better understanding on the concept of academic success, an overview of possible models of academic success is given below.

In any educational programme, a primary question is how one defines the criteria of successful performance. The so-called "criterion problem" has always been an important issue in validating admissions tests (Willingham, 1985). Various measures are used to define success, for example, grades, comprehensive examinations, and so on. Such measures serve as a principal or at least partial basis for evaluating student progress. Obviously the question of defining the criteria of success lies at the heart of the educational programmes. Nonetheless, there is limited literature on the problem as it applies to graduate study (Astin, 1993). Notions of what constitutes successful student performance and how it ought to be measured naturally vary widely across institutions, disciplines and types of programmes. It is very much a responsibility of individual institutions and departments to wrestle with an issue so central to educational policy.

Research conducted on academic success models suggests that student behaviour is both academic and social. According to Tinto (1993) a student may be able to achieve integration into the academic domain of college but fail adequately to achieve integration into the social side and therefore drop out. Conversely, a student may achieve integration into the social domain of college, but fail to persist due to lack of integration into the academic side. He further states that academic performance in the first semester of first-year students is crucial to their perception of comfort, integration into the tertiary community, and ultimate academic success.

When people speak of success in graduate school or "the criterion" of successful graduate student performance, more often than not they are referring to grades in one form or another (Willingham, 1985). Along with the criterion of degree attainment, grades have been used more than any other criterion in studies of graduate school success.

In thinking about "success" it is useful to differentiate immediate, intermediate, and ultimate criteria (Thorndike, 1986). Grades and end-of-year examination results are immediate criteria; career success is the ultimate criterion. The question is: which is the more appropriate basis for judging the validity of selection measures?

Academic success and student ability to succeed have been defined in many ways. Prominent educators include traditional academic success models (intellectual or cognitive ability), non-traditional academic success models (non-cognitive student development), and persistence toward degree attainment in these definitions (Astin, 1993; Pascarella & Terenzini, 1991; Tinto, 1993). The following are possible academic success models as described by various researchers such as Astin (1993), Mouw and Khanna (1993), Pascarella and Terenzini (1991), Tinto (1993) and many others as indicated below.

### **2.5.1 Traditional models of academic success**

According to traditional models of academic success, academic success is achieved intellectually through curriculum and classroom instruction (Astin, 1993; Oakes, 1990; Sax, 1992; Solomon, 1985). The student develops intellectually through cognitive learning and demonstrates academic success through traditional measures such as grades (Astin, 1993). Traditional cognitive measures such as standardised tests and high school grades tend to predict academic success. High-standardised test scores and high pre-university grades

are strongly related to academic success (National Science Foundation, 1998; Oakes, 1990).

Willingham (1985) examined a number of factors, such as aptitude, students' grade point averages, motivation and so on to determine which would best predict college grades. He found that the best indicator of future performance at a tertiary level was past performance in high school. Standardised test scores were the second-best predictor of tertiary grades. Data in his longitudinal study showed that these test scores predicted future performance almost as well as high school grades. The standardised tests were found to be valid predictors of first-year tertiary grades (Willingham, 1985).

Various writers have argued that traditional measures used for graduate and undergraduate admissions place undue emphasis upon a strictly scholastic view of education; for example, aptitude tests and grades do not recognise a diversity of purpose among disciplines and institutions, nor do they recognise the clear fact that the educational objectives of most faculty and most institutions are broader than pure academic competence (Baird, 1996; Richards, Holland & Lutz, 1987; Wallace, 1996; Wing and Wallach, 1981).

Research on college academic success demonstrates that the intellectual predictors of student ability account for just one part of academic performance. Pre-college academic ability cannot totally account for college academic success (Astin, 1993; Mouw & Khanna, 1993; Pascarella & Terenzini, 1991; Tinto, 1993).

However, Levin and Wyckoff (1994) concluded that the intellectual variables demonstrated a commonly held belief that the best predictor of future performance is past performance and that high academic achievement contributes to a student's decision to persist. These researchers analysed five intellectual, nine non-intellectual and five academic performance variables using the performance of students at the end of their sophomore year of baccalaureate

engineering study as the dependent variable. The sample of participants used in the study represented 65% of the population of engineering students who entered a programme as freshmen at Penn State University in 1984. The outcome of this research revealed that previous academic achievement was the best predictor of academic success.

However, Sparks (1989) states that grades at the graduate level may not provide meaningful descriptions of differential student performance, yet they are frequently used in determining the allocation of opportunities and rewards on the assumption that they report something specific and significant. A second shortcoming of grades is the obvious fact that grading standards can and do vary dramatically and sometimes arbitrarily across disciplines and within disciplines across different institutions (Bowers, 1987; Goldman and Slaughter, 1986; Juola, 1988). As a result, grades are practically useless as a criterion for multi-institutional comparative studies of student performance. Additionally, different grading standards means that special statistical techniques are necessary (Wilson, 1988) in order to combine data across institutions (within the same discipline) for validity studies, a strategy that is sometimes desirable owing to the small number of students within one department.

Research has determined specific problems associated with reliance on traditional measures of cognitive ability as accurate predictors of academic success (Burton & Ramist, 2001). High school grades used as predictors of college grades cover a broad range of both academic and non-academic skills but are limited in terms of reliability when making comparisons between students. Standardised test scores used in admission criteria are reliable when used to compare student aptitude but provide a limited view of academic knowledge and little or no measure of non-academic skills (Burton & Ramist, 2001; Kobrin & Milewski, 2002).

Researchers have demonstrated another problem in the limited ability of traditional predictors to offer a high correlation between past success and future persistence in tertiary education (Burton & Ramist, 2001; Levin & Wyckoff, 1994; Tracey & Sedlacek, 1984). High school grades indicate past achievement in specific subjects and many standardised tests were designed to predict the grades of first-year students and not academic achievement beyond the first-year students (Sedlacek & Adams-Gaston, 1989; Stern & Briggs, 2001; Willingham, 1985).

Earlier research conducted by Linn and Werts (1981) showed that the reported results of studies on predictive measures could be misleading if important measures used in admission decisions are omitted from the study of predictors. Research that includes a wider range of predictors other than those used in admission criteria at a particular institution might provide improved admission procedures (Burton & Ramist, 2001).

### **2.5.2 Non-traditional models of academic success**

While intellectual measures can be a strong cognitive predictor of academic success in various study programmes, non-cognitive factors also appear to affect student success (Astin, 1993; Oakes, 1990; Sax, 1992; Solomon, 1985). Efforts have been made by researchers to understand better how certain non-cognitive factors affect how a student achieves academic success, measured in terms of non-cognitive variables, and contributing to learning and development of personal characteristics that can help students achieve in the classroom. These characteristics include students' personal values, interpersonal interaction, intercultural values, socially responsible behaviour, healthy relationships and career objectives (Astin, 1993; Tinto, 1993; Tracey & Sedlacek, 1987). Research has identified non-cognitive variables that lead to academic success. These factors include social and academic integration, interaction and experiences with peers and faculty, student demographic characteristics, career and vocational goals,

and degree of involvement in the institution (Astin, 1993; Pascarella & Terenzini, 1991; Tinto, 1993).

Non-cognitive or affective learning occurs through experiences in and outside of the classroom. Success is determined by the development of personal affective skills acquired by the student and the resulting changes in behavior (Astin, 1993; Pascarella & Terenzini, 1991; Tinto, 1993). Research suggests that these non-cognitive variables have statistical relationships to predictions of academic success similar to the relationships found with the traditional cognitive variables (Ancis & Sedlacek, 1997; Larose & Roy, 1995; Levin & Wycoff, 1994, 1995; Mouw & Khanna, 1993; Tracey & Sedlacek, 1984). Mouw and Khanna (1993) concluded that factors other than pre-college intellectual ability determine college academic success.

A correlation has been noted between first-year academic performance, a student's adjustment to tertiary life, and future academic success (Kobrin & Milewski, 2002). First-year grades may be the single most revealing indicator of successful adjustment to the intellectual demands of a particular college's course of study (Pascarella & Terenzini, 1991). Researchers found that high school grades and standardised test scores were related to first-year college grades and were useful in predicting student academic achievement in relation to admission and placement decisions (Mouw & Khanna, 1993; Willingham, 1985). These studies indicate the significant contribution of non-cognitive variables as predictors of academic success of students over time as well as first semester first-year student's grades (Burton & Ramist, 2001; Sedlacek, 1987).

Willingham (1985) cited several non-cognitive variables that increased accurate predictions including a commitment to success in one or more areas, self-knowledge and ability to communicate this insight to others and educational resources. Burton and Ramist (2001) reviewed all of the current research on predictive ability of high school grades and standardised test scores from the

Senior Aptitude Test (SAT). This review revealed that non-academic factors contribute to student academic success. Their study concluded that although the high school grades and Senior Aptitude Test (SAT) scores consistently made predictions of first-year students' ability that were substantially accurate, supplementing these traditional measures with measures of non-cognitive predictors would further improve the validity of admission decisions.

### **2.5.3 Final qualification attainment as measure of academic success**

Whether or not one earns the degree has frequently been used as a criterion for validating graduate school admissions criteria. In fact, degree attainment has been employed in validity studies as often as the grade-point average (Willingham, 1984).

There are several reasons that support degree attainment as a useful and important criterion of graduate student performance. It is generally regarded as the single most important criterion of success (Tinto, 1993). Researchers who take this position argue that all other administrative criteria, grades, faculty ratings, etc., are simply poor proxies for what really counts. Graduate students clearly regard the attainment of their degree as the most important outcome of their graduate studies. A careful analysis of degree attainment as a performance criterion requires an understanding of the factors related to student failure to complete their studies (Tinto, 1993).

Students who drop out of tertiary education and do not graduate are not considered as academically successful against those who graduate (Tinto, 1993). Knowing that many students drop out of tertiary study programmes because of other reasons, rather than necessary intellectual shortcomings, is useful in at least two respects. First, it underscores the inevitable fact that predictors that are primarily academic in nature, undergraduate grades and standardised test scores, for example, will rarely be highly correlated with degree

or diploma attainment when only those with the highest grades and test scores are admitted to those programmes in the first place. Second, such findings help us understand what other sorts of human qualities are required for successful performance in high-level academic activities, and thereby suggest a number of relevant human characteristics to assess as potentially useful additional predictors.

Beyond this logistical shortcoming, however, there is another difficulty with degree attainment as a criterion. Research indicates that graduate students frequently withdraw or dropout of tertiary institutions for reasons such as emotional, family, health, or financial problems (Tucker, Gottlieb, & Pease, 1984). However, the real reason for withdrawing may never be learned, which complicates research of this nature.

While grades serve several useful functions in graduate education, the one served least well is that of providing an understandable criterion of graduate student performance. Even here it is important to remember that as one of several indicators of student performance, grades are relevant and useful. (Halleck, 1986) Their numerous limitations as a sole criterion should not detract from their value as one piece of the overall student evaluation puzzle. Careful definition of the right signs of success is important not only because it influences who gets selected, it also helps to focus the educational effort in the right direction (Halleck, 1986).

There are several classical criterion problems that apply to most selection situations in education. These can be grouped conveniently as problems concerning reliability, intrinsic validity and the range of success measures normally used (Gulliksen, 1986). This point is related to a third type of deficiency frequently noted in criterion measures as the range of competencies included. Even if the criterion is a reasonably good reflection of successful overall performance, it may be that some extremely important but relatively rare type of



determination may compensate for these limitations and even allow students with limited proficiency to succeed (Cummins, 1984). The role of language must not be overstated, as language is the only one of many factors contributing to academic success. However, there appears to be a threshold of proficiency below which students are unlikely to cope with academic study. According to Gravatt, Richards and Lewis (1997), language skills are the most important requirement for the first-year academic study across a range of subjects.

In this index, in the SPEEX, the respondent is asked to select either a word or statement from five options which, when combined with the given statement makes the whole statement meaningful. The index assesses the potential to use language for effective communication at a relatively advanced level of proficiency.

### **2.6.2 Reading comprehension**

Reading comprehension is defined as the potential or capacity to read and understand what has been read clearly and objectively (Erasmus & Minnaar, 1999). Some of the most stimulating research (Evans, 1992, Kokong, 1991) recently undertaken within cognitive science relates to reading and the processes underlying it. It is thus appropriate that educational problems, most of which relate in some way to reading and writing should be considered from a theoretical perspective that is grounded in cognitive linguistic.

Reading comprehension encompasses processes requiring skills that underpin every aspect of learning across the academic curriculum (De Beaugrande, 1980, Paris et al, 1990, Evans, 1995). When students struggle to understand concepts that assume a basic (sometimes very basic) grasp of mathematical reasoning, the distinction between language competence and mathematical competence becomes blurred. It is true that mathematical concepts are acquired through language (Saville-Troike, 1991). To the extent that language and mathematics

proficiencies are necessary conditions for tertiary education, students who fall in the low competence categories could be described as under prepared for university study. Language enhances students' comprehension, thereby improving academic performance (Saville-Troike, 1991).

In this index in the SPEEX, the respondent is given five minutes to read a passage and is then asked questions on the contents of the passage. He or she is not allowed to return to the passage once the questions are being answered. This index assesses the testee's competency to read and understand clearly what the reading matter conveys.

### **2.6.3 Perception**

Perception is defined as the potential or capacity to perceive objects correctly and in visual detail (Erasmus & Minnaar, 1999). Psychological studies of success and failure in our society reveal that one of the most important characteristics of successful people is accurate perception (Lohman, 1979). Therefore, it may be possible to reason that those people with realistic perception have sound judgment, which can lead to success.

According to research done by Potter and Van der Merwe (2001), visual imagery influence academic performance in engineering. Not only do practising engineers report using visual images as an essential part of the design process, but many teachers of engineering graphics state that visualisation forms an integral part of the courses they teach. In line with Piagetian theory on perception and mental imagery, Potter and Van der Merwe (2001), found that students vary in their ability to use mental imagery. Those students with well-developed abilities in mental imagery for the purposes of visualisation are likely to express few difficulties in learning the different methods of graphical illustration which engineers use in practice. In contrast, those students who lack visualisation

ability experience difficulty in learning the conventions of engineering drawing and applying these problems to design.

In this index in the SPEEX, the respondent is expected to identify the one illustration that is different from four similar illustrations. This index assesses the potential to perceive correctly and in visual detail as well as wholes in their specific, logical and sensible context.

#### **2.6.4 Advanced calculations**

Advanced calculations are defined as the potential or capacity to work and deal with numbers and figures of advanced complexity (Erasmus & Minnaar, 1999). Various studies have shown that when number ability is added to verbal ability, the variance explained by this combination of variables is larger, than when verbal ability alone is used. Various researchers regard this combination as the intellectual general ability (Minnie, 1974, Von Mollendorf, 1978, Van der Westhuizen, 1987).

Research done to determine the relationship between mathematical ability and success in school subjects (Minnie, 1974; Von Mollendorf, 1978; Van der Westhuizen, 1987) indicated that number comprehension has a significant relationship with academic success in most school subjects. Number comprehension on the Academic Aptitude Tests (AAT-5) was found to correlate above 0,5 with mathematics, while mathematical proficiency test (AAT-10) was reported to have correlations with exceed 0,7 with success in mathematics in standard 10/grade 12 (Minnie, 1974 & Von Mollendorp, 1978). In a study by Boney (1966) the correlation between number ability and the GPA was reported to be about 0,67 and 0,62 for boys and girls respectively. Omizo (1980) found lower correlation coefficients when he correlated success in science, the Grade Point Average and mathematics with number ability.

In this index in the SPEEX, the respondent is instructed to read through a number of numerical calculations, work out the correct solution and select a correct answer from five possible answers provided. It is expected of the testee to reason along logical and mathematical lines.

#### **2.6.5 Conceptualisation**

Conceptualisation is defined as the potential or capacity to reason in spatial terms; to see the relationship between parts; to complete the picture, to envisage the whole or-result, to anticipate the outcome (Erasmus & Minnaar, 1999).

Research by Potter and Van der Merwe (2001) has indicated that a level of spatial ability at time of intake to university is an important influence on academic performance. With respect to academic performance over the academic year, school performance and matriculation results were the best predictors, accounting for roughly 30% of the variance in academic performance in each first-year subject with the exception of the Engineering Graphic course. In the Engineering Graphics course, tests of three-dimensional spatial perception were better predictors, accounting for 24% of the variance (Potter & Van der Merwe, 2001).

Given the consistency of these findings with broader evidence that three-dimensional spatial perception predicted success in Engineering Graphics at other South African universities, it was logical to use scores on tests of three-dimensional spatial perception as a means of identifying student risks with respects to passing the course. This conclusion was reinforced by the findings of previous predictive studies conducted by Potter and Van der Merwe (2001), which indicated clearly that students with low levels of spatial ability (and in particular low levels of three dimensional spatial perception) at time of intake to the university were at risk, and would be unlikely to pass the first-year Engineering Graphics course without remedial intervention.

In this index in the SPEEX, a figure is provided on the left hand side of a page and five options provided from which the respondent must select one, which when combined with the figure already given would complete the picture or make it whole. The respondent may also mentally turn the figures around to be able to come up with the correct option. This index assesses the potential or capacity to reason in spatial terms, to see relationships between parts and to envisage the end-result.

#### **2.6.6 Assembling**

Assembling is defined as the potential or capacity 'to put together', to arrange parts into a whole or wholes of more advanced complexity or sophistication (Erasmus & Minnaar, 1999). According to the National Council of Teachers of Mathematics (2000), the ability to describe figures and visualise what they look like when they are transformed through rotations are important aspects of geometry in the lower grades. They further state that students with an integration or organisation disability find it difficult to make bits of information cohere into concepts. This is further confirmed by research on psycho-educational assessment (Anon, 1999), which indicates that high scores in assembly tests indicate excellent visual organisation abilities, good perceptual-motor coordination, all of which are primary components of academic functioning. On the contrary, low scores indicate problems with visual concept formation, pattern formation and synthesis.

In this index in the SPEEX, the respondent is provided with 14 pieces (puzzles) of a picture and they have to fit the puzzles together into a meaningful picture. The testee has to synthesise small parts into an organised, integrated whole. This capacity seems to involve both visual perception and logical reasoning. It furthermore demands a capacity for concrete reasoning in terms of figures and forms and their logical place within a single structure. The testee has to be able to visualise the desired end-result in order to be able to perform the task.

### **2.6.7 Insight**

Insight is defined as the potential or capacity to understand; to see the wood for the forest; to grasp; to reflect foresight; intuition; vision; wisdom (Erasmus & Minnaar, 1999). According to research done by Langrehr (2002), problem-solving is a hallmark of mathematical activity and a major means of developing mathematical knowledge. Steinberg & Wagner (1982) state that problem-solving abilities occur when one is able to process information rapidly and uses insight abilities. Creativity and problem-solving play an important role in academic achievement.

In this index in the SPEEX, the respondent is instructed to read through a riddle and decide which one of the five options provided is the correct solution. Insight, in this context, refers to the ability to create new concepts and solutions to problems, rather than sticking to old and tried ways. This ability seems to involve both creativity and problem solving.

### **2.6.8 Comparison**

Comparison is defined as the potential or capacity to compare, to align, to put together parts of an object (Erasmus & Minnaar, 1999). According to Langrehr (2002), when young students solve problems that involve comparing and completing collections by using counting strategies, they develop a better understanding of addition and subtraction and the relationship between these operations. High scores on comparison tests indicate good classification skills and the ability to make abstract connections. The ability to add and subtract as well as to reason in abstract terms are generally viewed as important components of success in mathematical courses such as engineering.

In this index in the SPEEX, the respondent is instructed to identify two identical illustrations amongst five almost similar ones. The capacity to perceive, analyse and synthesise is assessed, as well as the ability to select and categorise. This ability seems to involve both reasoning and conceptual thinking ability.

#### **2.6.9 Observance**

Observance is defined as the potential or capacity to pay attention, to be 'sharp' or alert (Erasmus & Minnaar, 1999).

According to Steinberg and Wagner (1982), high scores indicate the ability to pay attention to detail, recognise essential visual information, alertness and good visual acuity. On the contrary, low scores indicate low concentration, poor visual organisation and may also indicate impulsiveness. As indicated by Potter and Van der Merwe (2001), visual imagery influences academic performance in engineering.

In this index in the SPEEX, the respondent is instructed to select from five options one item that does not go along with the other four. This index assesses the potential or capacity to pay attention (mental alertness). This index requires the respondent to identify the sole deviation from five seemingly related objects. This ability is, according to the developers, associated with the ability to classify objects correctly. Schaap (1997) refers to the fact that this index is associated with the general mental ability (or G-factor) of the testee.

For the purpose of this study, only the specific abilities discussed above will be assessed to illustrate the extent to which they predict academic success of students.

## **2.7 CHAPTER SUMMARY**

In this chapter a working definition of academic success were given. Access to tertiary institutions and the use of psychometric tests for admission purposes were also discussed. Models of academic success were given. This was followed by a discussion on the relationship between certain cognitive variables and academic success. The review was done in order to determine the relationship of academic success with the selected SPEEX indices.

Chapter 3 focuses on the empirical study.



## **CHAPTER 3**

### **EMPIRICAL STUDY**

In this chapter the method used for the empirical study is discussed. The focus is on the choice and compilation of the study population, the measuring battery, the administration and scoring of the measuring instruments, as well as the relevant statistical analysis. Research hypotheses are also stated in terms of the present study.

#### **3.1 STUDY POPULATION**

Subsequently the study population is discussed with the focus on its composition and characteristics.

The study population consists of all first-year Mechanical Engineering students for the year 2000 and 2001 registration periods. All enrolled first-year Mechanical Engineering students serve as the population of the study (N=140).

The characteristics of the sample are shown in Table 1.

**Table 1**

**Characteristics of the mechanical engineering students**

Characteristic	Category	N	%
Gender	Male	131	94
	Female	9	6
Age	20-29 years	132	94
	30-34 years	8	6
Race	Black	127	91
	White	13	9

The students were sampled in order to provide enough data for testing the hypothesis that relates to the influence of the SPEEX on the prediction of academic success. All registered first-year mechanical engineering students were subjected to psychometric testing using the SPEEX. All the students who managed to sit for their semester examination were included in the sample. This method was selected in order to cover possible discrepancies between the number of students tested during the first semester of 2000 / 2001 and the number of students who wrote the first-year examinations at the end of the 2000 / 2001 due to dropping-out. If this were not catered for, it would have resulted in a reduction in the number of students in the final sample which would probably drastically affect the results.

### **3.2 MEASURING BATTERY**

The Situation Specific Evaluation Expert (SPEEX) instrument was included in the measuring battery.

#### **3.2.1 Situation Specific Evaluation Expert (SPEEX)**

In this section the rationale and development, description, administration and scoring, interpretation, reliability and validity as well as the motivation for the choice of the SPEEX are discussed.

##### **3.2.1.1 *Development and rationale of the SPEEX***

The primary aim of the government's Reconstruction and Development Programme (RDP) was the optimisation of human potential and provision of sufficient opportunities for all to become economically independent (Erasmus & Minnaar, 1999). An important prerequisite of this goal is the ability to accurately determine the potential of people to equip them to perform the right job at the right level and thereby avoiding any wastage of talent or corporate spending. The

need for a scientific approach to people development therefore became imperative, which in turn led to the development of the SPEEX (Erasmus & Minnaar, 1999).

The SPEEX is a registered South African psychological instrument which was developed by Pieter Erasmus and Gawie Minnaar as an advanced battery from the Potential Index Batteries (PIB), for the purpose of establishing potential in areas of human performance (Erasmus & Minnaar, 1995; McFarlane, 1998). This assessment tool has been highly rated in terms of culture fairness and is widely used in industry. The SPEEX consists of a series of culturally-fair, computerised, flexible and comprehensive tests aimed at illiterate, semi-literate and academically advanced individuals alike. The SPEEX's visual scales are language-free, and can thus be used with candidates regardless of the language they speak. It is divided into two broad categories namely visual tests and pen and paper tests. It comprises six separate batteries each aimed at a specific population. Each separate battery is divided into a number of indices (Erasmus & Minnaar, 1995; 1997). The indices are aimed at the screening of potential in various cognitive, emotional and social dimensions (Erasmus & Minnaar, 1997). All batteries can be administered either individually or in groups (Erasmus & Minnaar, 1995). The SPEEX is standardised for respondents of sixteen years and older, regardless of race, culture or gender. According to Erasmus and Minnaar (1995, 1997) the different test batteries can be used for a wide variety of purposes, including affirmative action, identification of training needs, selection and placement, psychotherapeutic interventions and counselling.

The SPEEX has many advantages for use in South Africa.

It is a South African test, which is widely used throughout South Africa.

It is a powerful test for both business and private purpose and the test can be used across a diverse range of people in a culturally fair manner. This is an aspect that is lacking in many international tests currently in use in South Africa

(Erasmus, 1997; 1999; Erasmus & Arumugam, 1998; Erasmus & Mamabolo, 1996; Erasmus & Minnaar, 1995).

According to Erasmus and Minnaar (1997), the SPEEX is the outcome of ongoing research and experience in the workplace across the nation, aiming at providing users with an assessment tool that guarantees internal reliabilities of 0,75 and higher with as few as 20 items per dimension.

The current study is concerned with only one of the pen and paper test batteries since it has been standardised for post-matric respondents, which is applicable to the current research population, namely a group of first-year students at the Vaal Triangle Technikon.

#### **3.2.1.2      *Description of the SPEEX***

The following SPEEX indices were selected as potential predictors of academic success based on their content validity (as indicated by the literature review) as well as the limitations and the nature of the study. The various SPEEX scales of human potential relate to the following dimensions or basic competencies. Only SPEEX indices that are relevant for this study will be discussed. Each relevant SPEEX index will be defined below in SPEEX terms.

##### **a)      *SPEEX 100-Conceptualization***

It is conceptualised in terms of the potential or capacity to reason in spatial terms; to see the relationship between parts; to complete the picture, to envisage the whole or result, to anticipate the outcome.

**b)     *SPEEX 302 –Advanced calculations***

This involves the potential or capacity to work and deal with numbers and figures of advanced complexity.

**c)     *SPEEX 400-Observance***

This involves the potential or capacity to pay attention, to be 'sharp' or alert.

**d)     *SPEEX 502-Assembling***

This category involves the potential or capacity 'to put together' or to arrange parts into a whole or wholes of more advanced complexity or sophistication.

**e)     *SPEEX 700-Comparison***

This involves the potential or capacity to compare, to align, to put together.

**f)     *SPEEX 800-Perception***

This involves the potential or capacity to perceive correctly and in visual detail.

**g)     *SPEEX 1000- Insight***

This section deals with the potential or capacity to understand; to see the wood for the trees; to grasp, to reflect foresight, intuition, vision, wisdom.

**h)     *SPEEX 1600-Reading Comprehension***

This has to do with the potential or capacity to read and understand what had been read clearly and objectively.

**i) *SPEEX 2502- Linguistic Proficiency***

This involves the potential or capacity to use the language of the workplace for purposes of effective job-related communication at a relatively advanced level of proficiency.

All of the above SPEEX indices represent the cognitive constructs of human potential as discussed in chapter 2.

**3.2.1.3 *Composition of the SPEEX.***

The aim of SPEEX in the present study is to serve as an objective, reliable and valid aid in guiding the selection of a course of study at a tertiary institution. Further this battery provides information on abilities such as the general intellectual ability, verbal and numerical ability and spatial abilities. Only the test composition of SPEEX battery that is relevant to the present study will be briefly discussed below.

**3.2.1.3.1 *General intellectual ability (intelligence)***

This battery does not measure general intelligence directly. The general intellectual ability is a common factor, which is the intersection of two factors, for example verbal and non-verbal and is therefore hypothetical. According to Minnie (1974) the scores on verbal and non-verbal ability should give a good indication of the individual's general intellectual ability. General ability plays an important role in the prediction of academic success.

#### **3.2.1.3.2      *Linguistic ability***

The tests which measure this ability are the following: SPEEX 1600 (Reading Comprehension) and SPEEX 2502 (Linguistic Proficiency). These tests are grouped under one factor, viz. verbal factor. The verbal ability tests assess the pupil's grasp of the verbal concepts and the relationship among them through the use of inductive and deductive reasoning (Erasmus & Minnaar, 1999). The two language tests consist of vocabulary and reading comprehension items. The scores on these tests give an indication of the pupils' language ability that is required for further studies. Both SPEEX 1600 (Reading Comprehension) and SPEEX 2502 (Linguistic Proficiency) respectively assess the potential or capacity to read and understand what had been read clearly and objectively and the potential or capacity to use the language of the workplace for the purposes of effective job-related communication at a relatively advanced level of proficiency (Erasmus & Minnaar, 1999).

#### **3.2.1.3.3 *Numerical ability***

For the purposes of this study, number ability is assessed by SPEEX 302 (advanced calculations). The advanced calculations test assesses the pupils' potential or capacity to work and deal with numbers and figures of advanced complexity (Erasmus & Minnaar, 1999). The test on numerical ability (advanced calculations) is also identified as a predictor of academic success of students in science and mathematics related courses at university/technikon. This ability is therefore important in predicting academic success of Mechanical Engineering students.

#### **3.2.1.3.4      *Spatial perception***

This ability is assessed by means of two-dimensional and three-dimensional spatial perception tests – SPEEX 100 (conceptualisation), which measure the

potential or capacity to reason in spatial terms, to see the relationship between parts, to complete the picture, to envisage the whole or result, to anticipate the outcome, SPEEX 700 (Comparison) which measures the potential or capacity to compare; align and to put together various objects and SPEEX 800 (Perception), which measures the potential or capacity to perceive correctly and in visual detail. These abilities are also critical to the prediction of academic success. Although there are reasonable correlations between the non-verbal and the verbal tests, between the linguistic and numerical proficiency tests, the inter-correlations justify the inclusion of all the tests in the battery.

#### *3.2.1.4 Administration and scoring of the SPEEX*

The SPEEX consists of 67 separate indices that contain between fifteen and one hundred questions depending on the index. For the purpose of this study, only the selected indices were administered, namely conceptualisation, observance, insight, perception, advanced calculations, reading comprehension, linguistic proficiency, assembling and comparison. The indices consist of a series of numbered statements which the respondent is requested to read and decide which of the five options offered is the most applicable or the correct answer to the specific question/statement. The respondent is then requested to mark his/her answer by means of colouring in or encoding in a circle of the SPEEX answer sheet provided. The respondent's answers on each index are entered into a computer and a scanner is used for scoring purposes. The scoring results are designed to score and convert all the scores for the individual indices in terms of a nine-point scale.

#### *3.2.1.5 Interpretation of the SPEEX*

The following interpretation is used for evaluating whether an applicant meets the requirements for entry into the Mechanical Engineering course or not.



**TABLE 2**

**Description of the SPEEX indices with a nine-point scale interpretation of the scores**

<b>SPEEX INDEX</b>	<b>POINTS ALLOCATED</b>
SPEEX 100 (Conceptualisation)	2
SPEEX 302 (Advanced calculations)	2
SPEEX 400 (Observance)	2
SPEEX 502 (Assembling)	1
SPEEX 700 (Comparison)	2
SPEEX 800 (Perception)	2
SPEEX 1000 (Insight)	2 (5-6)
	3 (7+)
SPEEX 1600 (Reading Comprehension)	2 (5-6)
	3 (7+)
SPEEX 2502 (Linguistic Proficiency)	2

Each student had to write each of the above indices. A student had to obtain a score of a 5 or above to get a mark in each of the indices. For example, if a student obtains a score of a 5 or more for SPEEX 100, the points allocated are 2. If he/she obtains a score of between 5 and 6 for SPEEX 1000 and SPEEX 1600 respectively, the points allocated are 2, however if he/she obtains a score of a 7 or above, he/she gets 3 points instead of 2.

A candidate is then evaluated as follows:

- 14+ Recommended
- 13 Borderline+ (above borderline score)
- 12 Borderline – (below borderline score)
- 11 Not recommended

When selecting students for entry into the course, the selection team considers the “recommended” candidates first (those who scored 14 marks and above), then the borderline + (those who scored 13 marks). Those who obtain a borderline score (those who scored 12 marks) are sometimes allowed access depending on availability of space in the course. Students who scored 11 marks and below are not recommended for enrolment for the course.

According to this evaluation, borderline scores indicate areas of weakness where there's a need for development. An above borderline candidate, for example, is an average candidate who would require attention in certain areas reflected by low SPEEX scores (such as a score of 4) in certain indices. A below borderline would, according to the evaluation, require more attention in certain areas as reflected by very low SPEEX scores (such as a score of 1, 2 or 3) in certain indices. Below borderline students may, for example, be recommended for bridging courses before entry to the course while an above borderline may be allowed entry but referred to for example, English language improvement classes.

#### 3.2.1.6 *Reliability and validity of the SPEEX*

Studies for determining the validity and reliability of the SPEEX have been undertaken by various researchers (Kriel, 1998; Erasmus, 1997; Schaap, 1996). Correlations between SPEEX indices and other standardised psychometric tests were found to be high. Schaap (1997) found correlations between the SPEEX and the 16 Personality Field Questionnaire to be as high as 0,70.

In a run-up to the study, correlations were calculated between the SPEEX indices and the Academic Aptitude Test (AAT). An accidental sample of 500 psychometric records of prospective students was used for this study. According to Dane (1990), an accidental sample is based on the availability or ease of inclusion. It was found that SPEEX 502 (Assembling) correlated significantly with

subset 1 of the AAT (Non-Verbal Reasoning) and with subset 9 (Spatial Perception). In the case of subset 1, a correlation of 0,49 and in the case of subset 9, a correlation of 0,48 was found. Index 800 (Perception) of the SPEEX correlated at 0,39 with subset 9 (Spatial Perception) of the AAT. SPEEX's index 400 (Observance) correlated with the AAT's subset 1 ( $r=0,58$ ), subset 2 ( $r=0,71$ ) and subset 9 ( $r=0,46$ ) (Schaap, 1997). Based on the above results, it seems that the SPEEX show construct validity and could therefore be used in this study.

In a study conducted by Schaap (1997), reliability coefficients as high as 0,93 were found for index 400 (Observance) of the SPEEX. Pilot studies undertaken by Technikon Pretoria rendered reliability coefficients for indices ranging from 0,69 to 0,96.

#### **3.2.1.7      *Motivation for using the SPEEX***

Two factors influenced the decision to use the Situation Specific Evaluation Expert (SPEEX) as a selection battery for first-year mechanical engineering students at the Vaal Triangle Technikon. Firstly, the availability of the instrument was important, but even more important was the fact that the instrument was developed in South Africa and regarded as culture-friendly. This made the instrument acceptable to the student bodies, especially the technikon's student representative council (SRC) and the technikon management with whom the writer had to enter into discussions regarding the intention to use the instrument as a selection battery.

### **3.3      RESEARCH PROCEDURE**

A research design can be defined as plan of procedures for data collection and analysis that are undertaken to evaluate a particular theoretical perspective (Guy, 1987). Research design refers to a plan for selecting subjects, research sites and data collection procedures to answer research questions (McMillan &

Schumacher, 1993). The goal of a sound research design is to ensure results that are credible.

**The following research procedure was followed:**

### ***3.3.1 Negotiations with management***

Before the SPEEX was administered at the Vaal Triangle Technikon, the writer had to first introduce it and negotiate with Management of the Technikon as well as the Technikon's student representative council (SRC) to have the SPEEX considered as one of the measuring instruments used to admit first-year students. The purpose of the negotiations was to make the SPEEX an acceptable instrument to use for access of first-year students as well as for the writer to have easy access to data to conduct the study. The writer wanted to limit the study to first-year Mechanical Engineering students; hence, top management from Mechanical Engineering department was also involved during the negotiations. The faculty of engineering where this study was conducted was cooperative with regard to the general use of psychometric assessment for admitting first-year students; so that, as a result, they easily accepted the use of the SPEEX as one of the measuring instruments for use in first-year admissions.

The procedure followed in this study is that students who applied for a National Diploma in Mechanical Engineering were evaluated by means of the SPEEX. The psychometric results of those students who were admitted to this course were included in the study as well as academic results that consisted of the final first-semester mark obtained by students in all required subjects. The final matriculation symbols obtained in Mathematics and Physical Science were obtained from the Academic Administration Department at the Vaal Triangle Technikon. The matriculation symbols were quantified according to the Vaal Triangle Technikon's Swedish formula and added to the equation as additional predictor variables.

For the purposes of this study, use was made of the matriculation results and additional course specific requirements specifically applicable to courses offered at the Vaal Triangle Technikon. The data consisted of the cognitive variables, measured by the SPEEX. For the sampled students, the writer was responsible for the application of these measures to assure uniformity in the testing procedure and the testing conditions. The tests were conducted in June and November 2000 and 2001 respectively. The answer sheets were scored by the optic reader and processed by computer at the Human Sciences Research Council (HSRC), Pretoria. At the end of 2000, the computer printouts that contained, in addition, data on the SPEEX were available. This necessitated the extraction of the required data only. A special form was then designed to collect data from the examination results of the first-year Mechanical Engineering students included in the sample, together with the data on the SPEEX. The intention of this study is to use the examination scores as the criterion. The criterion scores will be obtained after the first-year students had written their semester examinations as set by the examinations board of the tertiary institution. The question papers for the different subjects are regarded in this study as standardised. The aggregate percentage is at least a 50% pass mark on subjects with two of those subjects being the major subjects.

### *3.3.2 Administration of the measuring instruments*

As indicated earlier, the SPEEX indices consist of a series of numbered statements which the respondent is requested to read and decide which of the five options offered is the most applicable or the correct answer to the specific question/statement. The respondent is then requested to mark his/her answer by means of colouring in or encoding in a circle of the SPEEX answer sheet provided. The respondent's answers on each index are entered into a computer and a scanner is used for scoring purposes. The scoring results are designed to score and convert all the scores for the individual indices in terms of a nine-point scale.

A biographical questionnaire was not included in the measuring battery as this information was available from the Technikon. After the questionnaire had been completed and received the data were statistically analysed.

### **3.4 STATISTICAL ANALYSIS**

The statistical analysis was carried out with the help of the SAS-program (SAS Institute, 2000). Descriptive statistics were used to analyse the data. Means, standard deviations, skewness and kurtosis were used to describe and compare results. Mean is used as a measure of central tendency. The standard deviation approximates the average distance that the individual scores from the mean. The higher the standard deviation, the greater the distance is on average, from the mean (Steyn, Smit, Du Toit & Strasheim, 1995). Two components of normality are skewness and kurtosis. Skewness has to do with the symmetry of the distribution; a skewed variable is a variable whose mean is not in the centre of the distribution. Kurtosis has to do with the peakedness of a distribution; a distribution is either too peaked (with short, thick tails) or too flat (with long, thin tails) (Tabachnick & Fidell, 2001).

A discriminant analysis was carried out to which combination of independent variables could be used to predict academic success of mechanical engineering students. The resulting discriminate function separates the students maximally. The assumption of discriminant analysis is that the independent variables are continuous but that the dependent variable is categorical (Kerlinger & Lee, 2000).

The multiple correlation coefficient ( $R$ ) is used to determine the correlations between the SPEEX dimensions and the average year marks. The multiple correlation coefficient is one of the links that bind together the various aspects of multiple regression and analysis of variance.  $R$  is the highest possible correlation between a least-squares linear composite of the independent variables and the observed dependent variables (Kerlinger & Lee, 2000).

A multiple regression analysis was conducted to determine the proportion of variance in the dependent variable (average year mark) that is predicted by the independent variables (SPEEX dimensions). The effect size (which indicates practical significance) in the case of multiple regression is given by the following formula (Steyn, 1999).

$$f^2 = R^2 / (1 - R^2)$$

A cut-off point of 0,35 (large effect (Steyn, 1999) ) was set for the practical significance of  $f^2$ .

The value of  $R^2$  is used to determine the proportion of the total variance of the dependent variable that is explained by the independent variables. The F-test is used to test if a significant regression exists between the independent and dependent variables. Steyn (1999) suggested that effect size is used together with multiple regression, especially when working with a total population. Choen (1988) suggested the following guidelines for effect size:

- $f^2 = 0,01$  – small effect
- $f^2 = 0,10$  – medium effect
- $f^2 = 0,35$  – large effect

### **3.5 FORMULATION OF HYPOTHESES**

In conjunction with the specific research objectives, the following research hypotheses are formulated:

H1: Practically significant relationships exist between conceptualisation, observance, insight, perception, linguistic proficiency, reading comprehension, assembling, comparison and advanced calculations and academic success.

H2: Practically significant relationships exist between Conceptualisation (SPEEX 100) and academic success.

H3: Practically significant relationships exist between Advanced Calculations (SPEEX 302) and academic success.

H4: Practically significant relationships exist between Comparison (SPEEX 700) and academic success.

H5: Practically significant relationships exist between Perception (SPEEX 800) and academic success.

H6: Practically significant relationships exist between Reading Comprehension (SPEEX 1600) and academic success.

### **3.6 CHAPTER SUMMARY**

This chapter dealt with the method used for the empirical study. The choice and compilation of the study population, measuring battery, administration and scoring of the measuring instrument were discussed, as well as relevant statistical analyses. Research hypotheses were stated in terms of the present study.

Chapter 4 deals with the reporting and discussion of results of the empirical study.



## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

In this chapter the results of the empirical study are reported and discussed. Firstly, the results are reported. The mean, standard deviation (*SD*), range skewness and kurtosis of the measuring instrument are reported. Correlation coefficients (*r*) between the different dimensions of the measuring instruments are given. The results of the discriminative and regression analysis are reported. Secondly, a discussion and interpretation of the results are given.

#### **4.1 RESULTS OF THE EMPIRICAL STUDY**

The results of the empirical study are reported in this paragraph. Firstly, the results of the descriptive statistics of the measuring instrument are reported and secondly the correlation coefficients between the variables of the measuring instrument are provided followed by the results of the discriminative and regression analysis.

##### ***4.1.1 Descriptive statistics of the measuring instrument***

The mean, standard deviation (*SD*), skewness and kurtosis of the measuring instrument are computed for the sample of mechanical engineering students.

##### **4.1.1.1 The Situation Specific Evaluation Expert (SPEEX)**

The descriptive statistics of the SPEEX for mechanical engineering students are reported in Table 3.

**Table 3***Descriptive Statistics of the SPEEX for mechanical engineering students*

Item	Mean	SD	Skewness	Kurtosis
SPEEX 100 - Conceptualisation	5,86	1,18	-0,10	-0,13
SPEEX 302 - Advanced Calculations	5,68	1,19	-0,32	0,70
SPEEX 400 - Observance	5,33	1,08	-0,25	-0,65
SPEEX 502- Assembling	5,84	2,27	-0,28	-1,05
SPEEX 700 - Comparison	5,46	1,17	-0,85	2,84
SPEEX 800 – Perception	5,44	1,76	-0,29	-0,40
SPEEX 1000 - Insight	4,19	1,67	-0,15	-0,38
SPEEX 1600 - Reading Comprehension	4,16	1,68	-0,27	-0,83
SPEEX 2502 – Linguistic Proficiency	7,59	1,79	-0,98	-0,36
SPEEX SCORE	12,26	3,33	-0,49	0,26

Regarding the skewness and kurtosis of the SPEEX, Table 3 shows that there is a slight deviation from 0 for most of the variables, which is an indication of a normally distributed population.

#### **4.2 THE RELATIONSHIP BETWEEN THE DIFFERENT VARIABLES OF THE SPEEX**

In this study correlation coefficients ( $r$ ) were used to determine the linear relationship between the variables of the SPEEX. The correlation coefficients between the different SPEEX variables for the sample group of mechanical engineering students are reported in Table 4.

**Table 4***Correlation Coefficients between the different SPEEX variables for mechanical engineering students*

Item	1	2	3	4	5	6	7	8	9	10
1.SPEEX 100 – Conceptualisation	.	.	.	.	.	.	.	.	.	.
2.SPEEX 302–Advanced Calculations	0,20	.	.	.	.	.	.	.	.	.
3.SPEEX 400 – Observance	0,30	0,30	.	.	.	.	.	.	.	.
4.SPEEX 502 – Assembling	0,35*	0,19	0,31*	.	.	.	.	.	.	.
5.SPEEX 700 – Comparison	0,04	0,09	0,20	0,19	.	.	.	.	.	.
6.SPEEX 800 – Perception	0,18	0,36*	0,34*	0,30	0,20	.	.	.	.	.
7.SPEEX 1000 – Insight	0,19	0,33*	0,21	0,21	0,17	0,30	.	.	.	.
8.SPEEX 1600 – Reading comprehension	0,11	0,14	0,09	0,03	0,09	0,06	0,23	.	.	.
9.SPEEX 2502 – Linguistic proficiency	0,18	0,14	0,19	0,13	0,13	0,20	0,30	0,31*	.	.
<hr/>										
* Correlation is practically significant $r > 0,30$ (Medium effect)										
** Correlation is practically significant $r > 0,50$ (Large effect)										

Table 4 shows that the following practically significant relationships exist in the study population:

Conceptualisation is significantly positively related (medium effect) to Assembling. Advanced Calculations is significantly positively related (medium effect) to Perception and Insight. Observance is significantly positively related (medium effect) to Assembling and Perception. Reading comprehension is significantly positively related (medium effect) to linguistic proficiency.

Mechanical engineering students who measure high on conceptualisation will also obtain higher scores on Assembling. Students who measure high on Advanced Calculations will also obtain higher scores on Perception and Insight. Students who measure high on Observance will also obtain higher scores on Assembling and Perception. Students who measure high on Reading comprehension also measure high on Linguistic Proficiency.

### 4.3 DISCRIMINANT ANALYSIS REGARDING THE SPEEX VARIABLES

A discriminant analysis was performed in order to determine which variables discriminate the failure and pass rates of the mechanical engineering students. The resulting linear discriminant function for mechanical engineering students is given in Table 5.

**Table 5**

*The Linear Discriminant Function for Mechanical Engineering students.*

Item	Fail	Pass
Constant	-36,23	-34,29
SPEEX 100 – Conceptualisation	2,37	2,62
SPEEX 302 – Advanced Calculations	3,01	2,78
SPEEX 400 – Observance	2,48	2,79
SPEEX 502 – Assembling	-0,22	-0,23
SPEEX 700 – Comparison	3,23	3,15
SPEEX 800 – Perception	-0,05	-0,08
SPEEX 1000– Insight	-0,85	-0,73
SPEEX 1600 – Reading Comprehension	0,27	0,18
SPEEX 2502 – Linguistic Proficiency	1,71	1,53

By applying the discriminant analysis, it was found that all the above listed variables should be retained for the discriminant analysis. Table 5 summarises the frequencies and percentages of mechanical engineering students that can be classified as failing or passing their diploma (based on these variables).

**Table 6**

*Classification of mechanical engineering students in failing or passing groups*

Group	Failing Rate	Passing Rate	Total
Failure Rate	23 (67,65%)	11(32,35%)	34(100%)
Pass Rate	44(44%)	56(56%)	100(100%)

Table 6 shows that the combination of variables of mechanical engineering students classifies correctly 67,65% of the mechanical engineering students failing their diploma and 56% passing their diploma. A total of 32,35% of the pass rate and 44% of the failure rate are classified incorrectly.

Finally a stepwise discriminant analysis was conducted. The variables that best predict the failure and pass rates of mechanical engineering students are given in Table 7.

**Table 7**

*Variables that predict failure or pass rates of mechanical engineering students.*

Variables	Partial <i>R</i> -Square	<i>F</i> -Value
SPEEX 2502 – Linguistic Proficiency	0,02	2,20

Table 7 shows that the variable, SPEEX 2502 (Linguistic Proficiency), can be used to predict failure or pass rates of mechanical engineering students.

#### **4.4 REGRESSION ANALYSIS REGARDING THE SPEEX VARIABLES**

A multiple regression analysis was conducted to determine the proportion of variance of academic success explained by the SPEEX. A significant level of  $p < 0,15$  was set.

The results of the regression analysis with average year mark as a dependent variable and the SPEEX indices as independent variables is indicated in Table 8.

**Table 8**

*Standard Multiple Regression with Average Year Mark as Dependent Variable (DV) and SPEEX indices as Independent Variable (IV).*

Variable	Parameter	Std. Err.	t	p
<b>DV = First Year Average Mark, IV = SPEEX Indices <math>F = 1,18^+ R^2 = 0,09</math></b>				
Intercept	51,61	8,26	6,25	-
SPEEX 100 - Conceptualisation	1,80	0,86	2,09	0,04
SPEEX 302 – Advanced Calculations	-0,86	0,85	-1,01	0,31
SPEEX 700 - Comparison	0,24	0,84	0,28	0,78
SPEEX 800 - Perception	0,35	0,56	0,62	0,54
SPEEX 1600 – Reading Comprehension	-0,23	0,54	-0,43	0,67
<b>DV = Second Year Average Mark, IV = SPEEX Indices <math>F = 2,90^+ R^2 = 0,190</math></b>				
Intercept	58,49	8,32	7,03	-
SPEEX 100 - Conceptualisation	1,28	0,87	1,48	0,14
SPEEX 302 – Advanced Calculations	1,39	0,86	1,62	0,11
SPEEX 700 - Comparison	-1,49	0,84	-1,76	0,08
SPEEX 800 - Perception	-0,43	0,56	-0,77	0,44
SPEEX 1600 – Reading Comprehension	-1,29	0,55	-2,36	0,02
<b>DV = Third Year Average Mark, IV = SPEEX Indices <math>F = 1,56^+ R^2 = 0,11</math></b>				
Intercept	52,53	11,07	4,75	-
SPEEX 100 - Conceptualisation	1,65	1,16	1,43	0,16
SPEEX 302 – Advanced Calculations	0,00	1,14	0,00	1,00
SPEEX 700 - Comparison	-0,98	1,12	-0,88	0,38
SPEEX 800 - Perception	0,94	0,75	1,26	0,21
SPEEX 1600 – Reading Comprehension	-1,16	0,72	-1,59	0,12
<b>DV = Fourth Year Average Mark, IV = SPEEX Indices <math>F = 2,06 R^2 = 0,14</math></b>				
Intercept	54,44	7,16	7,61	-
SPEEX 100 - Conceptualisation	1,58	0,75	2,11	0,04
SPEEX 302 – Advanced Calculations	0,17	0,74	0,23	0,82
SPEEX 700 - Comparison	-0,74	0,73	-1,02	0,31
SPEEX 800 - Perception	0,23	0,48	0,48	0,63
SPEEX 1600 – Reading Comprehension	-0,88	0,47	-1,87	0,07

• Statistically significant –  $p < 0,0001$

+  $f^2 = 0,15$  – practically significant (medium effect)

Table 8 shows that Conceptualisation, Advanced Calculations, Comparison, Perception and Reading Comprehension as measured by the SPEEX, predict 9% of the variance in the First Year average mark. The unique variances explained by the independent variables were practically significant. It is evident from the results that SPEEX 100 (conceptualisation) is contributing.

Conceptualisation, Advanced Calculations, Comparison, Perception and Reading Comprehension as measured by the SPEEX, predict 19% of the variance in the Second Year average mark. The unique variances explained by the independent variables were not practically significant.

Conceptualisation, Advanced Calculations, Comparison, Perception and Reading Comprehension as measured by the SPEEX, predict 11% of the variance in the Third Year average mark. The unique variances explained by the independent variables were practically significant.

Conceptualisation, Advanced Calculations, Comparison, Perception and Reading Comprehension as measured by the SPEEX, predict 19% of the variance in the Final Year average mark. The unique variances explained by the independent variables were not practically significant.

## **4.5 DISCUSSION**

The objective of this research was to determine the validity of the Situation Specific Evaluation Expert (SPEEX) as a predictor of academic success of first year Mechanical Engineering students. The descriptive statistics indicate that the population is normally distributed.

Significant relationships were found between conceptualisation and assembling and between advanced calculations and perception and insight. Significant relationships were also found between observance and assembling and perception and between reading comprehension and linguistic proficiency. Results from this study indicate that mechanical engineering students who measure high on conceptualisation will also obtain higher scores on assembling and students who measure high on

advanced calculations will obtain higher scores on perception and insight. Students who measure high on observance will obtain higher scores on assembling and perception and students who measure high on reading comprehension also measure high on linguistic proficiency.

Results from the discriminate analysis indicate that SPEEX 2502 (linguistic proficiency) could be used to predict the academic success of mechanical engineering students. The combination of the different variables in the study predicted 67,65% correctly, students failing their diploma and 56% correctly, students passing their diploma. A total of 32,35% of the passing rate and 44% of the failing rate were classified incorrectly.

A multiple regression analysis was conducted to determine the proportion of variance of academic success explained by the SPEEX. The results of the regression analysis indicate that 9% of the variance was explained in the First Year mark, 19% in the Second Year mark, 11% in the Third Year mark and 19% in the Final Year mark. The unique variances explained by the independent variable were not overall necessarily practical significant.

#### **4.6 CHAPTER SUMMARY**

In this chapter, the results of the empirical study were reported and discussed. The descriptive statistics of the measuring instrument were reported. A discriminant analysis and regression analysis were done. The results were discussed.

In Chapter 5 conclusions and limitations are discussed and recommendations are made.



## **CHAPTER 5**

### **CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS**

In this chapter conclusions will be drawn regarding the literature review and the empirical study, the limitations of the study will be highlighted and recommendations will be made for further studies.

#### **5.1 CONCLUSIONS**

In this section, conclusions will be drawn in terms of specific theoretical objectives and the results of the empirical study.

##### *5.1.1 Conclusions in terms of specific theoretical objectives*

The results of the study revealed that the accurate selection of Mechanical Engineering students is only possible to a certain extent, with certain SPEEX indices correlating positively with academic success while others showed a negative correlation.

The use of the SPEEX as a selection instrument for Mechanical engineering students is not seen as the only method to be considered for future selection, due to contributions of other predictors of academic success such as motivation, persistence and so on. It has, however, strengthened the validity of the selection procedures and increased the possibility for selection transparency. The study indicated the areas in which the selection mechanism was valid, but also the aspects of it that were not justifiable.

The expansion of the traditional selection procedure to include the SPEEX proved valuable, as the validity of certain prediction models improved with the addition of the indices from the SPEEX. The incorporation of the suggested

Situation Specific assessment battery in selection process could contribute to increased and broadened participation in higher education because the instrument focuses on assessing potential to succeed as opposed ability to succeed.

#### *5.1.2 Conclusions in terms of specific empirical objectives*

The results of the statistical analysis performed on the research data proved that not all the indices included in the Situation Specific Evaluation Expert made a significant contribution to the prediction of academic success in the Mechanical Engineering course. Only one index of the SPEEX, SPEEX 2502 (Linguistic Proficiency) did make consistent contributions to the prediction of academic success in the Mechanical Engineering course.

It is also clear from the results of the study that certain indices of the SPEEX played a significant role (as seen from the significant correlations, medium effect from the results in chapter 4) in the prediction of academic success in the Mechanical Engineering course.

The reliability and consistency of the criterion scores used in this study are questioned (as seen from the report of the results in chapter 4) and therefore should be investigated.

A disturbingly high standard error of estimate was found throughout the study. This could possibly be ascribed to the unreliability of the criterion scores used in this study, which might be explained by the fact that the academic results of students were obtained over a period of three years as well as the fact that even students that were not recommended for entry into Mechanical engineering course were also admitted into the course.

## **5.2 LIMITATIONS**

The limitations of this study are discussed below.

- As indicated in chapter 2 of this study, there are various possible models of academic success, which included traditional models such as aptitude or intellectual abilities as well as non traditional models such as motivation, commitment, academic integration and so on. The current study only included traditional models. As a result it can be concluded that the exclusion of the other factors (non traditional factors such as motivation) in the contingent of possible predictors may have had a negative influence on the validity of the prediction model. It can also be said that no single psychometric assessment instrument (including potential as well as situation specific assessment) will ever correlate perfectly with academic success because other factors other than intellectual abilities / potential will always play a role.
- In the current study, academic success is defined as obtaining a pass mark in a subject, passing of an academic year and a final qualification, a diploma (Raijmakers, 1993). However, there is difficulty with qualification attainment as a criterion. Research indicates that graduate students frequently withdraw or dropout of tertiary institutions for reasons such as emotional, family, health, or financial problems (Tucker, Gottlieb, & Pease, 1984). However, the real reason for withdrawing may never be learned, which complicates a research of this nature.
- As indicated in chapter 1, a definition of academic success by Raijmakers (1993) included the ability to transfer skills learned in theoretical context to real life situations (the working environment). It could, therefore be argued that academic performance is not the only relevant measurement when it comes to the selection of students. Other aspects such as such as performance on the actual job could also be considered as relevant.

selection battery procedure for Mechanical Engineering students as well as other science courses. It is also important to conduct an empirical study of those in-house admission tests before they are implemented.

- The reliability and consistency of the criterion scores are lacking in this study, and should therefore be investigated. It is proposed that all prospective Mechanical Engineering students be evaluated with the same battery and that different weights be allocated to different indices, as determined by the prediction models. It would then be possible to implement an advisory selection system where the most suitable course for a candidate according to his/her potential profile could be recommended. It is further recommended that this study be repeated for the rest of the Engineering courses at the Vaal Triangle Technikon in order to establish prediction models for those courses and to ensure advisory selection process functions optimally.
- According to McMillan & Schumacher (1993), predictions involving short time spans are usually more accurate than those where there is a long time span between the assessment of the predictor and criterion variables. It is, therefore recommended that a study is undertaken to monitor the eventual success of students admitted by means of the selection procedure suggested here.
- Anastasi (1998); Kriel (1998); Magnusson (1967) & Smith (1996), state that a test does not have fixed coefficient of validity, which are applicable for every purpose and for every group of individual for which it might possibly be used. A test has a high or low validity for the specific purpose for which it is used, as well as for the group within which it has to discriminate. Based on the above comments, it is recommended that if the Situation Specific Evaluation Expert battery is to be used in a selection context where the characteristics of the applicant pool differ from the sample used here, or where the programme for which students are selected differ significantly from the Mechanical Engineering course used as criterion variables in this study, the effectiveness

and fairness of the Situation Specific Evaluation Expert will have to be re-evaluated for the new context.

- It is recommended that prior knowledge of Mathematics as a predictor of academic success in engineering courses and as represented by the symbol obtained in the final high school examination, should not be negated.
- It is recommended that Situation Specific Evaluation Expert battery for Mechanical Engineering should consist at least Linguistic Proficiency, Conceptualisation, Observance, Assembling, Advanced calculations, Perception, Insight, Reading Comprehension.
- It is recommended that further research is conducted on the Situation Specific Evaluation Expert as an assessment instrument to allow future researchers to have more literature available on the instrument to draw from.

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