TR 80-12

VALIDATION OF A PREDICTOR BATTERY FOR ENGINEERING TECHNICIANS

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PREFACE

I wish to express my appreciation for the assistance received from the following:

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My family and friends for their support and encouragement.

OPSOMMING

Hierdie verslag beskryf 'n prosedure van kursussuksesvoorspelling vir sekere eerstetermyn ingenieurstegnici. Die doel van die studie is om die hoë uitsaksyfer onder leerling-ingenieurstegnici te reduseer deur die vroeë identifisering van potensiële druipelinge. Dié identifisering geskied deur die onderwerping van alle kursusapplikante aan sielkudige toetsbatterye. Die verkreë informasie dien as voorspelling ten opsigte van applikante se eerstetermyn kursusresultate.

Daar word aanbeveel dat studentvoorligters, verbonde aan die verskeie Technikons, die voorgestelde prosedure in 'n plooibare beroepsvoorligtingsdiens vir ingenieurstegnici integreer. Daar moet egter in gedagte gehou word dat geen geldigheidstudie toekomssukses honderd persent akkuraat kan voorspel nie en tweedens dat die onderhawige studie spesifiek mag wees ten opsigte van die Witwatersrandse Technikon.

Hoofstuk 1 bevat 'n omskrywing van die agtergrond en doel van die studie, asook enkele algemene oorwegings ten opsigte van geldigheidstudies.

Hoofstuk 2 beskryf die ontwikkeling van ingenieurstegnici opleiding en die vraag en aanbod vir ingenieurstegnici in Suid-Afrika.

Hoofstuk 3 bevat 'n navorsingsoorsig ten opsigte van die voorspelling van ingenieurssukses deur middel van verskillende voorspellingskategorieë.

Hoofstuk 4 beskryf die ingenieurstegnicisteekproef, die voorspellers en kriteria van sukses soos toegepas tydens hierdie studie.

Hoofstuk 5 bevat die resultate van vergelykings tussen die onderskeie subgroepe.

Hoofstuk 6 bevat die korrelasie- en regressie-ontledings wat op die onderskei subgroepe uitgevoer is, as ook 'n bespreking van die praktiese implementering van bevindinge.

Hoofstuk 7 omskryf die algemene raamwerk vir die toepassing van bevindinge, stel 'n keuringstrategie voor en doen aanbevelings ten opsigte van toekomstige navorsingsgebeide.

Die Aanhangsel bevat,onder andere, norms wat aan die hand van die eksperimentele groepe bereken is vir gebruik deur studentevoorligters tydens die implementering van die bevindinge van hierdie ondersoek.

SUMMARY

This study describes a procedure for predicting course success for certain first term engineering technicians. The aim of the study is to reduce the high attrition rate of trainee engineering technicians through the early identification of candidates who are likely to fail their first term of study. This identification is done by testing all applicants to the courses on a battery of psychological tests, and from this information estimating the applicants' first term course results. It is suggested that the student counsellors attached to the various Technikons integrate the suggested procedure into a flexible vocational guidance service for engineering technicians. It should be borne in mind that no validation study can predict future success with a hundred percent accuracy, and that the sample used in this study may be specific to the Witwatersrand Technikon.

Chapter 1 contains an outline of the background and purpose of the study and some general considerations of validation studies.

Chapter 2 describes the development of engineering technician training and the supply of and demand for engineering technicians in South Africa.

Chapter 3 contains an overview of research into the prediction of engineering success using various categories of predictors.

Chapter 4 describes the sample of engineering technicians, the predictors and the criteria of success used in the study.

Chapter 5 contains the results of the comparisons of the various sample sub groups.

Chapter 6 contains the correlation and regression analyses carried out on the various sub groups and a discussion on the practical implementation of the findings.

Chapter 7 outlines the general framework for the application of the findings, proposes a selection strategy and suggests areas for further research.

The Appendix contains, inter alia, norms calculated from experimental groups, for use by student counsellors in applying the findings of this study.

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CHAPTER ONE

1. INTRODUCTION

1.1 Background

The present study was motivated by a concern about the high failure and drop-out rate occurring amongst trainee engineering technicians at Technikons. At present, the growth of the South African economy is being retarded by its inability to obtain enough of the highly trained technicians who are essential to a very wide range of industries. Present practice suggests that the demand for such personnel will be met largely by suitably trained Whites. This places a heavy training burden on the shoulders of the six Technikons open to White students.

The comparatively new development of the National Diploma and Certificate (introduced in 1957) as an alternative type of advanced (i.e. post standard ten) education has resulted in Technikons having to compete with universities for a share of matriculants who have the ability to pass the courses offered. Unfortunately, Technikons are often regarded as being only second training choices, since a diploma does not offer as high a status as a degree. These are some of the problems affecting Technikons, and one of the manifestations of these difficulties is the low proportion of technicians who complete the course as against those who enrol. Campbell-Pitt (1970) estimates that only 25% of students enrolling for the National Diploma for Technicians actually obtain the qualification.

The Witwatersrand Technikon is concerned about the problem of unsatisfactory academic progress of its students, and this problem was brought to the attention of the Federation of Societies of Professional Engineers (FSPE), whose predominant concern is for technicians being trained in the engineering field. The problem should be seen against the backdrop of the following factors:

(i) The growing demand in South Africa for highly trained technicians;

ii) The high cost of training technicians, (recently estimated to be in the vicinity of R20 000) which is borne by the employers of trainee technicians;

iii) The waste of training facilities which are expended on large numbers of unsuitable pupil technicians who do not complete the course.

The present investigation was undertaken by the author as a research project at the National Institute for Personnel Research. The NIPR was approached by the Federation of Societies of Professional Engineers to look into the problem of the high failure rate occurring amongst engineering technicians and to suggest ways of improving the pass rate. The development of a selection device is one approach to this problem.

1.2 Purpose of the Present Study

The aim of this investigation is to validate a predictor battery in order to reduce the high attrition rate of first term engineering technicians at the Witwatersrand Technikon. The purpose of the selection strategy will be to predict whether the applicant is likely to pass the course or not. It is envisaged that those who are unlikely to pass will be counselled by vocational guidance officers attached to the Technikons, who will, where necessary, redirect these students to careers better suited to their abilities. It is felt that if the criterion of course success can be satisfactorily predicted then the envisaged course of action will significantly reduce the high drop out and failure rate of engineering technicians and the associated wastage of human resources.

1.3 Outline of the Validation Strategy

In this study, the experimental group was all first trimester students who enrolled for the civil, mechanical and electrical (light current) Diploma Courses at the Witwatersrand Technikon between September 1975 and May 1976. These Diploma courses were selected because of the preponderance of enrolments in them.

Biographical information was obtained from standard forms completed by all subjects and a number of ability tests and an interest questionnaire were administered to the groups; this provided the independent variables for the study. The dependent variables were the end of term examination marks obtained by the students.

Optimal predictions of success in the courses were obtained by multiple regression analyses. Also tested at the same time as the experimental group were all final term students doing the same engineering courses as the experimental group. This was done in order to see on which independent variables a "successful" (i.e. final term) sample of engineering technicians differed from the experimental group. This could prove useful in compiling the final predictor battery. This strategy aims at providing a selection procedure which will predict on the basis of the independent variables whether the applicant student technician is likely to pass his first term of study at the Technikon or not. The nature of the exercise requires that acessible quantitative measures be used to predict success in order to construct an economic yet effective selection procedure. It should, however, be borne in mind that important variables such as personality, motivation and adjustment have not been considered in any depth in this thesis. This is because such measures are seldom found to act as successful predictors in mechanistic prediction formulae. Only trained psychologists should use such information within the context of the individual's background.

1.4 General Consideration of Validity Studies

Predictive validity is an indication of the effectiveness of a test or battery of tests in predicting behaviour in specified situations. The behaviour being predicted is referred to as the criterion. The information provided by predictive validity is most relevant to tests used for the selection and classification of personnel.

The primary concern in a predictive validity study is to obtain as high a correlation as possible between the predictors and the criterion. Such correlations are not all-or-none properties, but are a matter of degree.

After deciding exactly how to measure the criterion, the validity of a prediction function is determined by correlating scores on the predictor tests with scores on the criterion variable. The size of the correlation is a direct indication of the amount of validity.

Nunnally (1967) makes the observation that in most prediction problems, it is unreasonable to expect high correlations between a criterion and predictor tests. People are too complex to permit a highly accurate estimate of their performance from any practicable collection of test materials, while no criterion or predictor measures can be totally accurate. The target group of the present investigation is especially problematic in this regard since the criterion being predicted is academic performance, yet the average student studying at a Technikon does not have a strong academic orientation, and variables such as motivation and adjustment would no doubt play an important part in predicting their academic performance.

However, Nunnally (1967) points out that even those tests which have only modest correlations with their criteria (e.g. correlations of 0,30 to 0,40) are often capable of markedly improving the average performance of personnel in various settings. Mistakes would be expected to occur in predicting the performance of individuals, but on the average, persons scoring high on the tests perform considerably better than persons scoring low on the tests:

> "Such differences in mean performance frequently are highly important in applied settings...... tests that have only modest correlations with their criteria can frequently make highly important improvements in the average performance of groups in educational institutions, industry, government services, and other activities." (Nunnally, 1967, p79).

A number of factors distort validity coefficients and complicate their interpretation. One of these factors is unreliability of the predictors and of the criterion being predicted. In the measurement of performance, the actual scores obtained are a combination of true scores and error, therefore the correlation of actual scores is a compromise between the correlation of the underlying true scores and the 0,00 correlation that characterizes the random errors. Another factor which distorts validity coefficients is restriction of the range of ability in the group by some type of preselection. By systematically reducing the spread of scores in any sample on which a validation study is being conducted, the correlation of test with criterion will normally be reduced (Thorndike and Hagen, 1955). This consideration should be borne in mind in the present study since a precondition for entrance into the Faculty of Engineering at the Technikons is matriculation exemption for Mathematics and Physical Science.

Another factor to bear in mind in validating a predictor battery is the supply and demand situation of the group being selected. If there are few applicants and many vacancies, even the most valid selection test will not reduce the number of poor performers since the situation will not lend itself to refusing applicants. On the other hand, if there is a high selection ratio, even a test with a low validity will yield large practical gains. In terms of the present study, the general shortage of engineering technicians will not be conducive to rejecting large numbers of applicants. However, the intention of this study is not to prescribe rigid, mechanistic procedures for the rejection of engineering technicians, but rather to provide the Student Counsellors with test information to be used in conjunction with other relevant background and personality variables for effective vocational guidance counselling. At the same time, by instituting selection criteria to be met by all applicants, a different and perhaps more attractive image, may be created for the engineering diploma course which could increase the number of applicants.

CHAPTER TWO

2. THE TRAINING OF ENGINEERING TECHNICIANS AND CONCOMITANT SELECTION NEEDS.

2.1 Definition of Terms

The engineering technician discussed in this study refers to those trainees who enter a Technikon to study for the National Diploma for Technicians in specific engineering fields. It has been suggested (Goode Report, 1978) that a distinction be made for registration purposes between technicians and technologists, but such a distinction is not necessary in the present study since both technicians and the proposed technologists do the same initial course, namely the NDT, which is used as the criterion of success. The engineering fields examined in this study include only the civil, mechanical and electrical (light current) specializations. Not all engineering fields were included since the above three attracted the majority of applicants in the Engineering Faculty of the Witwatersrand Technikon.
The sample of students tested were White and predominantly English and Afrikaans speaking.

2.2 Background Information on Engineering Technician Training.

The advances made in science and Technology during the past four decades have resulted in a reassessment of the training and utilization of manpower in this area. Greater emphasis on scientific background and creative ability is being placed on the training of professional engineers, resulting in more of the routine tasks of production, maintenance and fault finding being allocated to the technician group. Advances in technology have also led to a demand for greater levels of sophistication in technician training.
The education of the Technician is more career orientated than that of the professional engineer. This leads to more emphasis falling on the study of the applicability and application of principles, rather than on the scientific study of principles. The aims of technician tuition and training, in theory and in practice (consisting of lectures,

laboratory work and where applicable,,practical workshop training at a Technikon) are listed in the Goode Report as follows:

a) the provision of an adequate scientific basis for the study of the technology within the particular area of interest;

b) providing a Technical education in the broad common core of technology applicable to the area of interest and such specialized technology as may be common to a number of employment possibilities within such area. Education in highly specialized technology only required by isolated employers is the responsibility of the individual employer during the period of in-service training;

c) preparing the technician so that by refresher courses of reading and self study he can keep abreast of development in his area of interest once he has left the Technikon;

d) Education in various forms of communication, such as written, drawing and oral.

The Goode Report points out that inherent in the aims of technical education lies the problem of meeting the following requirements simultaneously, namely:

i) the provision of a sound scientific foundation for the understanding of the Technology and the ability to develop the self;

ii) the introduction of the Technology from the time that the student commences his technical classes (Goode, 1978 p.52).

A solution to this problem is sought in the use of the sandwich system, which allows the trainee a portion of each year in which to obtain on-the-job training, and practical laboratory exercises during his period at the Technikon.

The practical work done by trainee engineering technicians is of a general (off-the-job) and specific (on-the-job) nature. The general practical work is usually done in laboratory experiments at Technikons, while the specific on-the-job practical work is obtained working with an employer, in between theoretical blocks at the Technikon. The purpose of the practical training is to induct the trainee into the work situation, to acquaint him with the widest range of engineering know-how in his particular specialization field, to assist him with the application of theoretical knowledge and scientific principles in practical situations, and to enable him to operate successfully on-the-job immediately after the completion of his course. Although the Goode Committee (1978) found that the education and training aspects of technicians could not be isolated from one another, this study will concern itself only with the prediction of academic results from the first part of the engineering technicians course, since it is during this phase that a large number of students fail or drop-out of the course.

Full-time "advanced" (i.e. post high school level) technical education is relatively new in South Africa. Up until 1957, advanced technical education was offered on a part-time basis only. This position changed after a conference called by the Department of Education, Arts and Science in 1956, which called for the initiation of full-time advanced technical education on a semester sandwich basis, leading to the National Diploma for Technicians (NDT). A new scheme of technical education was introduced in 1972 resulting in the phasing-out of the National Technical Diploma, and the introduction of new Certificate and Diploma Courses for technicians. The N3 replaced the NTC course and the T examinations replaced the NTC 4 and 5. The present requirements for the Certificate course are that the T1, T2 and T3 courses be completed over a minimum period of 3 years. Each sandwich course is made up of four subjects, and a total of 360 hours instruction is necessary. The Diploma courses are offered only at Technikons and the T1, T2, T3 and T4 courses must be completed over a minimum time period of 4 years. Each "T" course is made up of six subjects and a total of 2160 hours tuition is required to obtain a Diploma. The pass mark stipulated for the Diploma course is 50 per cent (for the Certificate the pass mark is 40 per cent), and minimum entrance requirements for an Engineering Diploma course are Standard 10 with acceptable

passes in mathematics and physical science, or an N3 Certificate. If "pre-technician" courses are satisfactorily completed, applicants without the necessary entrance qualifications can gain entrance to the course.
The Goode Report (1978) found that replies to a widely distributed questionnaire indicated greatest interest in the expansion of education at the NDT level. The Committee has recommended that the present four year NDT be replaced by a restructured three year National Diploma course, consisting of three semesters at a Technikon, with the balance as in-service training. It proposed that this be convertible to a NCT for students unable to pass the NDT, providing that they passed six T1 and six T2 subjects at a 50 per cent level and obtained at least 40 per cent in each of four T3 subjects. The Committee recommended further that the present NDT holders or students passing six T4 subjects at the 50 per cent level with the necessary in-service training be awarded a Higher National Diploma (HND), and that further study at a Technikon beyond the HND (T5 and T6) should be awarded the proposed Diploma in Technology (Dip Tech) (Goode, 1978, p69).

In assessing generally the existing standard of technician training in South Africa, the Goode Report (1978) states that the technical education system in South Africa compares favourably with those overseas:

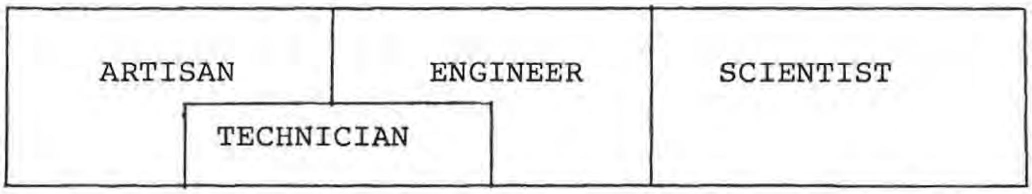
> "Features not common elsewhere are the emphasis on practical training in making NDT and NCT awards, and the integration between the specialized and narrow certificate courses and the broader diploma courses.... The NDT technician may be considered to be among the best prepared in the world. He is fully capable of doing a worth-while job when awarded his diploma. He has completed a course in technical training similar to that of the continentally trained 'engineer' but with rather more emphasis towards the industry in which he has done his practical training. The sandwich course system has enabled him to absorb an above average technical content during his tuition periods." (Goode, 1978, p13)

2.3 The Engineering Team

Up to the second World War, the members of the engineering team are described (Goode Report, 1978) as falling into three classes - scientists, engineer, and artisan, while the group now called technicians were either advanced artisans, highly skilled craftsmen or foremen and controllers of operations. Such people were few in number, and not identified as belonging to a distinct class of worker. The members of the team are represented in Figure 2.1, with the most practically orientated being on the left side and the most theoretically orientated on the right.

FIGURE 2.1

THE ENGINEERING TEAM BEFORE WORLD WAR II



(After Goode, 1978, p6)

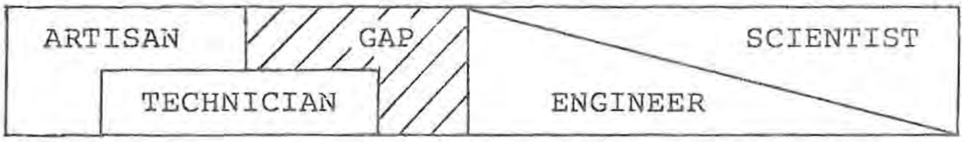
During World War II, top scientists were primarily involved in the development of advanced weaponry and defence systems; few engineers had the scientific knowledge to participate in these projects, which led to the inclusion of more basic science content in engineering courses so as to qualify more engineers to take part in sophisticated technological developments.

As a result, many of the practical engineering courses were dropped. The gap between scientist and engineer was thus closed, but a new gap was opened between the artisan and the engineer which created new opportunities for upgraded artisans or technicians.

This position is represented in Figure 2.2

FIGURE 2.2

REPRESENTATION OF THE ENGINEERING TEAM DURING THE 1950's



(After Goode, 1978, p6)

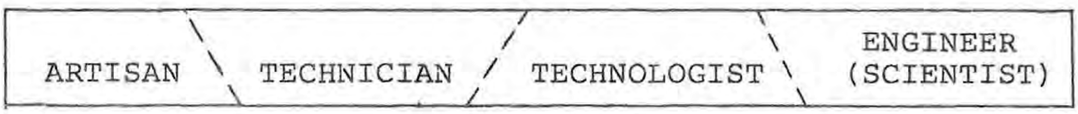
Recognition of the need for better trained technicians was early in the U.K. and U.S.A.
Definitions of "Professional Engineer" and "Engineering Technician" were formulated and adopted at the 1954 combined conference of the Engineering Societies of Western Europe and the U.S.A., and the Conference of Engineering Institutions in the Commonwealth. This gave wide recognition to the engineering technician, whose work was defined as:

> "... any of the specialized categories of technical work between those of the craftsman and the professional engineer."
>
> (Goode, 1978, p7)

This recognition marked the beginning of the establishment of full-time technical education in many countries.
During the 1960's the gap between artisan and engineer had become so large that many Western countries began expanding technician education above secondary school level. However the gap was further widened as university engineering curricula became more scientifically sophisticated, and this created a need for better educated technicians. This led, in the U.S.A., to the establishment of a four year course leading to a Ba Degree in engineering technology. These graduates were called technologists (Goode, 1978 p7).
The engineering team of the 1970's in the U.S.A. is represented below:

FIGURE 2.3

REPRESENTATION OF THE ENGINEERING TEAM OF THE 1970's IN THE U.S.A.



(After Goode, 1978, p7)

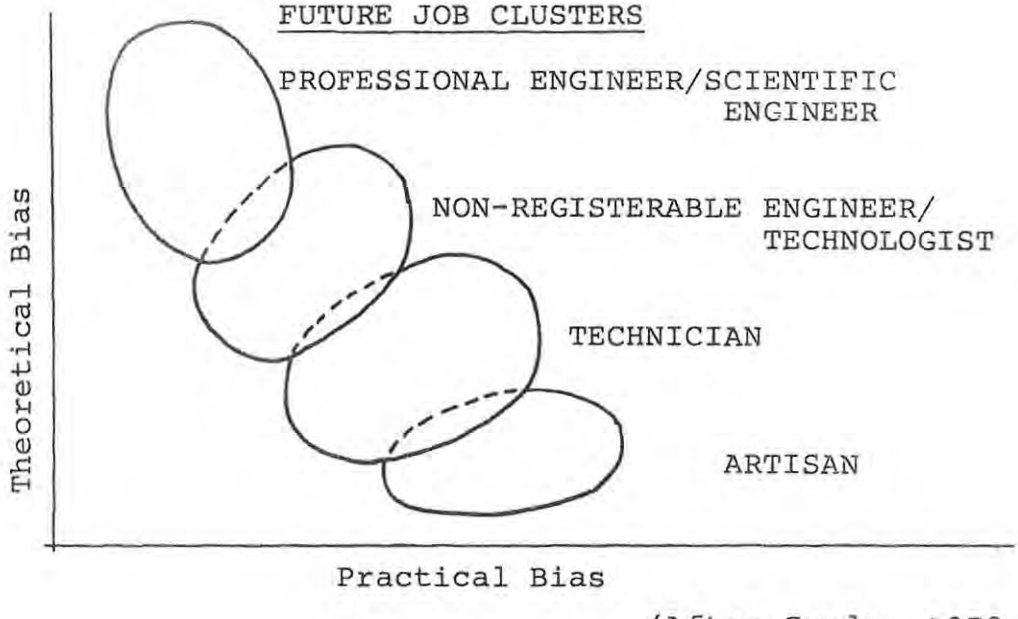
The boundaries between the different grades cannot be clearly defined, and internationally, many names are used to refer to the category of workers operating between the engineer and the artisan levels.
However the description given in the ASEE Report (1972) by the Engineers Council for Professional Development (of the U.S.A.) of engineering technology indicates on which end of the continuum the technicians field is:

> "... that part of Technological fields which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational area between the craftsman and the engineer at the end of the area closest to the engineer."
>
> (In Goode, 1978, p8)

The Goode Committee describes the engineering team of the future as constituted by clusters of job designations ranging from practice to theory as represented in Figure 2.4. It is suggested that there can be overlapping by the members of the technical team into non-technical aspects such as manpower and sales.

FIGURE 2.4

FUTURE JOB CLUSTERS



(After Goode, 1978, p9)

2.4 Supply and Demand Considerations with regard to Human Resources in the Engineering Field

The rapid development of the Republic of South Africa has been largely manifested in the growth of her infrastructure. Large scale engineering projects are numerous and include, for example, the Sishen-Saldanha projects; the development of Richard's Bay; motor way and road developments; dam building and irrigation schemes; city growth and expansion of necessary services, etc. In order to sustain such growth, essential manpower skills must increase. Figures from the Department of Labour indicate that the number of White engineers increased by 24,2% from 1973 to 1975, while for the same time period the general growth of white labour was 3,5%. However, figures also reveal that despite the higher than average increase in the numbers of engineers, the manpower shortage in this field was 6,2% as against the general labour shortage of 3,5% in 1975.

The Goode Committee found from their survey that the largest shortage of Technicians was the NDT group and higher. Employers indicated that they wanted at least twice the present number of the above-mentioned category of Technicians. The Committee notes that if South Africa's industrial development is to continue, an increasing population must receive higher level technical education, and it endorses as still valid the Straszacker Commission's (Straszacker, 1965) suggestion that the number of qualified Technicians be trebled, and the number of graduate engineers be doubled.

The Goode Committee found at the time of their survey (1975) that a supply of over 400 NDT awards are made annually, having increased at the rate of some 27 per cent per annum since 1973. However, this is about half the number of engineers graduating from universities. Bearing in mind that it has been recommended that the number of professional engineers be doubled (Straszacker, 1965), and that a number of professional societies have recommended a ratio of three technicians to every one professional engineer, the size of the shortfall in the supply of engineering Technicians can be seen. The Goode Committee found that the biggest demand was for holders of Diplomas in production and civil engineering.

In attempting to quantify the shortage of technicians in the RSA, Bloch (1976, p.15) encountered two problems which have led him to query the validity of official figures. The problems are:

a) the lack of a clearly defined or accepted job category of "technician."

b) Reluctance of employers to define some classes of workers as technicians in case Government regulations are contravened.

The 1971 Survey (Department of Labour, Manpower Survey) reported that a "Shortages/Vacancies" figure of only 332 engineering technicians existed whereas in 1972 an analysis presented to the Sixth Conference of FSPE showed a shortfall of 17 392 engineering technicians. The size of the discrepancies existing in official statistics can thus be appreciated.

Bloch (1976) undertook a survey of 104 firms to see what their projected needs for Black technicians would be in the year 1981. He found that 505 Africans with Diplomas or Certificates would be employed immediately if they were available, and the firms surveyed expected a demand for 1 271 African technicians by 1981. Judging from general attitudes that presently exist in South Africa and assuming that pay scales are racially non-discriminatory in 1981, it is probable that most firms would opt for employing European technicians in preference to African technicians; it is suggested that the demand for African technicians by the year 1981 (as reported by Bloch) should be small in comparison to the demand for European technicians if the South African and World economies have recovered from the present recession.

The Shortage of engineering technicians indicates the urgent need for increasing the rate of training to keep abreast of the demand. Bloch (1976) notes that:

> "...the 'skills shortage', which certainly exists, is likely to extend far into the future and put an increasingly nagging brake on the engine of economic development. It is clear, if we accept the evidence of the Manpower Surveys alone, that the Whites cannot provide the skills needed by South Africa's very rapidly expanding population." (p.19)

Bloch (1976) points out that according to official statistics, the average annual number of Diplomas (all types) awarded during the ten years 1962-1971 was 485, (or 651 from 1967-1971). In comparison, 8 473 Bachelor Degrees (all types) were awarded in 1973. Such a small proportion of Diplomas obtained points towards an imbalance in the structure of South Africa's educational system.

2.5 Ratio of Technicians to Engineers

Information obtained by the Goode Committee indicates that an overall ratio of technicians to professional engineers is a meaningless figure. Such wide variations occur in different work sectors and different branches of engineering that it is necessary to look at each branch or work sector separately. From their survey of technicians qualified at above the N3 level, (representative of all geographical areas and all work sectors except small private businesses and mining companies) the Committee found that electrical engineering had the largest ratio of technicians to professional engineers namely 4,76:1. The lowest ratio was in the civil (0,84:1) and chemical (0,83:1) engineering fields. In relation to work sectors, the ratio extremes are: electrical, Semi-State service - 11,13:1; civil, Private - 0,18:1. Adding all draftsmen to the latter group raises the ratio to 0,24:1.

A possible explanation given for the low ratio of technicians in the civil and chemical branches is the lack of designated trades in these two fields. The Committee of Inquiry also found in their survey that almost half of all technicians are employed in Semi-State crganisations, followed by the Private Sector (± 25%), then State, Public Corporations and Research Organisations (all having ± 10% each). State, Provincial and Local Authorities train as many as 50% of their technicians to the Diploma level, and Public Corporations, the Private Sector and Research Organisations require one Diploma technician to every two lower level technicians.

Finally, it appears from official and unofficial figures that not enough engineering technicians are being trained to meet the demand for them in South Africa. The most obvious way to find the necessary man-power is to improve the training facilities of Blacks at all levels. Between 1965 and 1974 only 43 Blacks obtained Diplomas as engineering technicians (Nienaber, 1975). The validation of a selection model for Whites is therefore only part of the answer in solving the problem of the shortage of engineering technicians in South Africa.

CHAPTER THREE

3. BACKGROUND RESEARCH IN PREDICTING ENGINEERING SUCCESS

3.1 Introduction

In looking at the basic requirements of engineering, Bingham (1937) pinpointed four basic abilities which he felt were necessary for success in the field: mathematical or numerical ability, spatial perception, mechanical comprehension and an aptitude for the physical sciences.
This was subsequently supported by Crawford and Burnham (1946) and Vaughn (1947), all working in the U S A. From research done in South Africa, Biesheuvel (1949) listed the following as the most important factors in engineering success:

i) General intelligence;
ii) Scholastic achievement especially in Mathematics and Science;
iii) Mathematical ability;
iv) Spatial ability (spatial orientation, perceptual accuracy and spatial imagination);
v) Mechanical comprehension/insight.

Other less important factors found by Biesheuvel were an interest in engineering and an interest in objects rather than people. Much work has been done to find out what factors are necessary for success in the engineering field, and these can be broadly split up into intellectual factors, non-intellectual personality factors and assorted background information.

3.2 Intellectual Factors as Predictors of Engineering Success

The intellectual factors examined include general intelligence, specific abilities and scholastic achievement as an application of intelligence. A brief overview is given of the development of psychological testing and the attendant growth of theory to explain findings.

3.2.1 Some landmarks in the development of intelligence testing

"Intelligence tests" are the direct descendants of the original Binet-Simon Scale. This was developed in 1905 in response to the establishment of a commission to study procedures for the education of subnormal children attending schools in Paris. The scale consisted of 30 problems or tests arranged in order of difficulty. The tests covered a wide variety of functions, with much emphasis on verbal comprehension, reasoning and judgement.

A second scale was developed in 1908 in which the number of tests were increased. Some unsatisfactory tests were removed, and the concept of "mental age" was introduced. Terman at Stanford University translated and revised the scale, which became known as the Stanford-Binet intelligence test. In this test, intelligence quotient (IQ) or the ratio of mental age to chronological age was introduced.

However, it became apparent after a while that the original motive or intelligence testing, namely, to assess an individuals general intellectual level, yielded only general information mainly about verbal ability. The construct being measured by intelligence tests is a somewhat vague measure of abilities that are of importance in our culture, and are usually closely linked to abilities demanded by academic work. It was soon realized that global intelligence measures were of less use than specific aptitude tests, and Rose (1979) notes that:

> "The assumption of a global 'general intelligence factor' has been discarded by most modern psychologists working on cognition as virtually useless for understanding the processes underlying 'intelligent behaviour'. The term merely obscures the interaction of specific and specialized cognitive processes" (p 849)

Multiple aptitude batteries have been developed from factor analysis studies, for the purpose of measuring individual performance on a number of specific factors such as language comprehension, numerical ability and spatial visualization.

The term "aptitude test" has come to refer to tests measuring relatively homogeneous and clearly defined abilities, whereas the term "intelligence test" refers to more heterogeneous tests yielding single global scores such as IQ (Anastasi, 1968).

The development of special aptitude tests has lead to much research and theorization about what separate factors make up intelligence. It became clear with the use of special aptitude tests that individuals generally showed marked variation in performance on different tests (Anastasi, 1968). With improvements in the methodological construction of tests, and the development of the factor analysis technique for interpreting new factors, evidence has been gathered indicating the presence of a number of relatively independant factors or traits. This led to significant advancement in the conceptualizations of the theory of the intellect. Using factor analysis techniques, it became possible to systematically examine the mathematical relationship existing between variables. This provided the basis for the trait theories of the structure of the intellect.

3.2.2 Correlation theories of the structure of the intellect

Psychological research can be divided into two major scientific orientations, namely, the experimental and the correlational (Cronbach, 1957). The former attempts to understand human behaviour through observation of controlled experiments, whereas the latter is concerned with the inter-relationships between variables measured in the natural state and the explanation of individual differences. Since the present study is conducted within the individual differences framework, some of the more important figures in the development of models of the intellect based on the individual differences approach will be briefly examined.

The first theoretical explanation of intelligence was produced in 1904 by Spearman. His theory provided the first theoretical rationale for intelligence testing and a framework for the development of intelligence tests. The correlations found by

Spearman (1904) between sensory tests and scholastic achievement led him to suggest that intellectual functions were linked but that a hierarchy of specific intelligences also existed. He proposed that a general factor, g, was common to performance on all mental tasks, but that a specific factor, s, was specific to each different task area. He likened g to general mental energy with which an individual is endowed, and suggested that experience and specific training would affect the development of s factors. Spearman postulated that mental activities could be ordered into a hierarchy based on their saturation with g. From this he concluded that the central mental function occurring in all cognitive operations is the education of relations and the education of correlates. He observed that activities highly saturated with g appear to depend more on this operation than operations lower in the hierarchy, which led him to equate g with the education of relations and the education of correlates. Spearman later suggested that the s factors were not entirely independent, and that some overlap occurred between them.

Burt (1940) further refined the factor analysis methodology, and proposed a hierarchical model of intelligence. The main difference between the theories of Burt and Spearman is that Burt postulated the existence of group factors intermediate between g and s factors. A general factor, g, was the origin of most variance, and when this variance was removed, common factors to a wide range of performances could still be identified. Two major group factors were postulated, namely, the verbal-educational (v:ed) and the spatial-mechanical (k.m). Within the major group factors were minor group factors. Burt described these as performance sets which were dependent on some common factor. When all the common variance was accounted for, Burt suggested that the variance left was specific to the performance itself, which could in turn be split into true and error variance.

Vernon (1961) used a similar model to Burt's, also with two major ability groups, v:ed and k:m (termed spatial-perceptual-practical). The two major groups are broken down by Vernon into more specialized group factors like fluency and number abilities on the v:ed side and spatial, mathematical and psychomotor abilities on the k:m side. Vernon resisted splitting these specialized group factors up into smaller, more specific factors, since he felt that this contributed nothing towards the understanding of ability. Vernon also noted that his hierarchical model was merely a taxonomical device and should not be regarded as a rigid model of the abilities of man.

Burt conceptualized intelligence as primarily genetically determined, and proposed that the development of the group factors were related strongly to maturational processes. Vernon adopted Hebb's (1949) idea of a genetic component of intelligence which determined the biological potential for growth (intelligence A), and the interaction of this potential with the environment (intelligence B). Intelligence A is therefore a purely theoretical construct since its effects can only be observed in interaction with environmental factors, which determines the extent to which its potential is realized. Intelligence B is subject to maturation under environmental stimulation, and can be measured as behaviour. Vernon (1965) suggested a third intelligence factor - intelligence C, which was an estimate of intelligence B, as measured by tests. This indicated his awareness of the pit-falls of trying to obtain accurate measures of basic human abilities. Vernon suggested that individuals develop abilities which best enable them to cope with their cultural environment, and he collected evidence to indicate the part played by the effect of particular environmental variables on intelligence B.

Thurstone developed a different explanation of human intelligence. He suggested that some mental functions were independent of general intelligence, and in a study using 56 tests administered to samples of college students, and schoolchildren, Thurstone identified seven clear factors (Thurstone and Thurstone, 1941). These factors were: Spatial Ability (S), Verbal Meaning (V), Verbal Fluency (W), Perceptual Speed (P), Memory (M), Numerical Ability (N) and Inductive Reasoning (R). The difference between Thurstone's model of the intellect and the earlier hierarchical models was, firstly, a departure from the belief in the unidimensionality of intelligence, and secondly, a novel way of interpreting factor analyses. However, this theory is not all that different from the hierarchical models, only that it started from the primary abilities and then progressed to second order factors which produced a single general factor similar to the g found at the first order by earlier theorists.

Guilford proposed a comprehensive structure of the intellect in which he attempted to relate all the intellectual components to one theoretical model. He found the primary abilities proposed by Thurstone insufficient to account for the observed relationships between tests, and so he suggested a three dimensional system for the classification of abilities (Guilford, 1956). The first dimension represents the basic psychological processes, which he termed operations. He suggested five categories of operations, namely, evaluation, cognition, memory, divergent production and convergent production. The second dimension classifies the material or content of the mental act, and four categories were proposed, namely, physical, symbolic, semantic and behavioural. The third dimension was used to classify the products which resulted from the application of the operations to the content. Six categories were proposed, namely, units, classes, relations, systems, transformations and implications. This three dimensional model yields 120 cells, which Guilford proposes as the totality of human abilities. This differs from the hierarchical model theorists who considered their factors to be merely a means of classification of mental processes.

Guilford's model has heuristic value and has also helped to integrate some of the diverse ideas of cognitive theorists, but on the negative side, it can be criticized for giving rise to an abundance of specific factors which do not have practical applications. Guilford has also been criticized for his statistical methods. Horn and Knapp (1973) have pointed out that his factor analytic technique yields results which can be obtained on random scores, thus charging that Guilford's model predetermines his findings.

The hierarchical models of the British factor analytic approach and the multiple factor models of the American theorists have been synthesized in Cattell's model of fluid and crystallized intelligence. Cattell (1943) views general intelligence as a second order factor, and conceptualized this general factor as being composed of both fluid intelligence (Gf) and crystallized intelligence (Gc). Fluid intelligence is described as the measurable outcome of the biological factors influencing intellectual development, while crystallized intelligence is described as the sum of skills acquired through the operation of fluid intelligence. Horn and Cattell (1966) later suggested that fluid and crystallized intelligence were not the only second order factors, but that general visualization, general fluency, general speed and carefulness should be included as second order factors.

The diversity of factor solutions to explain human intelligence indicates that no universal system for representing the structure of intellect is likely to come from the psychometric approach. However, the evidence indicating the existence of individual differences, and the need for predicting future performance from existing differences will act as an incentive to find practical workable models of the structure of the intellect.

The approach of this study is to accept the synthesized model of the structure of human intelligence, and to use measures of general intelligence and specific abilities as predictors of engineering success.

3.2.3 Research in prediction of engineering success using measures of general intelligence.

Much research has been done in America into the relationship between general intelligence and engineering ability. Pintner (1932) found that correlations between the two variables varied from 0,19 to 0,61 while researchers in South Africa (Gouws (1957), Baard (1956))found correlations which varied from 0,23 to 0,42. Van Tonder (1969) reported that IQ (as measured by the New South African Group Test) correlated at 0,21 for males and 0,31 for females with first year university success in the physical sciences. Although this correlation was found to be significant at the 1% level, the NSAG Test is not designed to discriminate amongst a relatively small homogeneous group and it therefore would have limited value in predicting success.

Smit (1976) found in a survey done on 435 first year technicians that most students enrolling for courses had IQ scores of between 89 and 111. The following table gives a more detailed breakdown of the intelligence structure of students entering Technikons.

TABLE 3.1

IQs OF STUDENTS ENTERING TECHNIKONS

IQ Scores	% of Group
88 or less	2,8
89 - 111	50,6
112 or more	46,7

(Smit, 1976)

Of the students with IQ scores between 89 and 111, 70,1% passed their first year of study, while 84,5% of the group with IQ scores higher than 112 passed their first year. These figures indicate an increased pass rate with higher IQ, but Smit excluded from his sample those who dropped out during their first year. Thus the intellectual structure of the drop-out group is unknown.

It appears from studies both in South Africa and abroad that measures of general intelligence play a consistently useful role as predictors of success in engineering Degree and

Diploma courses.

3.2.4 Research in prediction of engineering success using measures of specific abilities.

In a large study carried out to establish how the predictive validity of a battery of ability tests varied (Vaughn, 1943/4), the Yale Aptitude Test battery was administered at five different colleges and correlations with first term engineering subjects were calculated (i.e. with engineering drawing, descriptive geometry and engineering problems). Correlations of the tests with a comprehensive criterion of first term academic results revealed the following variations:

TABLE 3.2

CORRELATIONS OF THE YALE APTITUDE TEST BATTERY WITH FIRST TERM ENGINEERING RESULTS.

Colleges	Tests						
	n	A	B	C	D	E	F
1	56	0,208	0,439	0,273	0,567	0,571	0,348
2	60	-0,041	0,150	0,376	0,182	0,394	0,175
3	196	0,112	0,012	0,161	0,347	0,151	0,186
4	201	*	0,235	0,399	0,396	0,449	0,286
5	293	*	0,223	0,377	0,446	0,358	0,301

* No figures available (From Vaughn, 1943/4)

KEY OF YALE APTITUDE TEST BATTERY

A. Verbal Comprehension
B. Artificial Language
C. Quantitative Reasoning
D. Spatial Visualization
E. Mathematical Aptitude
F. Mechanical Ingenuity

It can be seen from the table that the tests which correlate best with first term academic results are the tests of Spatial Visualization, Mathematical Aptitude and Quantitative Reasoning. Predictive validity of this test battery varies between the samples, but uncontrolled criterion variables include different standards of lecturing and examining, different interpretations of syllabi and various selection strategies used by the colleges.

Vaughn (1947/8) later suggested that there are four factors which are necessary for success at an engineering college, namely:

- i) Ability to understand and interpret scientific material;
- ii) General mathematical ability;
- iii) Ability to understand mechanical principles; and
- iv) Spatial perception.

Vaughn (1947/8) developed a test battery intended to measure the above-mentioned abilities in order to predict the academic achievement of students at ten engineering colleges. The tests used in this "Pre-Engineering Inventory" are given in Table 3.3

TABLE 3.3

CORRELATIONS OF THE PRE-ENGINEERING INVENTORY WITH FIRST SEMESTER RESULTS OF ENGINEERING STUDENTS

Tests	Range of Coefficients	Median r
1. General Verbal Ability	0,16 - 0,50	0,38
2. Technical Verbal Ability	0,25 - 0,55	0,47
3. Comprehension of Scientific Material	0,41 - 0,65	0,55
4. General Mathematical Ability	0,57 - 0,71	0,62
5. Comprehension of Mechanical Principles	0,30 - 0,55	0,39
6. Spatial Visualizing Ability	0,22 - 0,42	0,35
7. Understanding of Modern Society	0,25 - 0,53	0,41
Composite Value	0,38 - 0,68	0,62

(From Vaughn 1947/8)

A continuation of this study was made by Lord et al (1950) who found that there was hardly any difference in correlation medians obtained from another twelve engineering colleges. The composite correlation value found was 0,60. This support for the "Pre-Engineering Inventory" indicates that it is a fairly effective predictor battery, of which the General Mathematical Ability and Comprehension of Scientific Materials tests appear to be the best predictors of success. Johnson (1955), using only these two tests found an average validity coefficient of 0,57 with first term examination results from 305 engineering students, and the same tests produced a validity coefficient of 0,68 with first semester examination marks from 260 engineering students at the Carnegie Institute of Technology.

In South Africa, Barnard (1969) attempted to predict academic success of English and Afrikaans first year engineering technicians at a Technikon using a battery of psychological tests. He tested 569 subjects of whom 86 were selected who had both matriculation exemption for mathematics and science and a combined stanine total of 26 or more on four ability tests and a test of general intelligence. These tests were correlated with marks achieved for five course subjects:

TABLE 3.4

TEST CORRELATIONS WITH FIRST TERM SUBJECTS AT A TECHNIKON

Test	n	Mathematics	Physics	Principles of Electricity	Applied Mechanics	Engineering Drawing
A/1	86	0,17	0,09	0,07	0,18	0,08
A/68	86	0,30	0,41	0,31	0,34	0,05
A/3	86	0,16	0,11	0,21	0,23	0,11
A/16	86	0,44	0,37	0,28	0,28	-0,10
A/80	86	-0,14	-0,06	0,12	0,04	0,40
Sum of Standard scores of all 5 tests	86	0,40	0,40	0,30	0,45	0,09

(Barnard, 1969)

KEY OF TESTS USED

A/1 - Mental Alertness Test

A/68 - Arithmetical Problems Test

A/3 - Mechanical Comprehension Test

A/16 - Mathematical Knowledge Test

A/80 - Blox Test

These results show a very poor correlation between the A/1 test and the criteria and Barnard (p269) has suggested the there is no link between general intelligence as measured by the A/1 test and academic achievement at a Technikon. The present study conceptualizes general intelligence as a second order factor in the structure of the intellect (after Cattell, 1966) and is thought likely that a measure of general intelligence would correlate with the academic criterion.

Barnard (1969) calculated the multiple correlation coefficients of the above tests with the criteria which yielded the following results :

TABLE 3.5

MULTIPLE CORRELATIONS OF TEST COMBINATIONS WITH FIRST TERM ENGINEERING SUBJECTS AT A TECHNIKON

Tests	n	Mathematics	Physics	Principles of Electricity	Applied Mechanics
A	86	0,52*	0,54*	0,41*	0,42*
B	86	-	-	0,33*	0,36*
C	86	-	-	0,37*	0,41*
D	86	-	-	0,44*	0,48*

* Significant at the 1% level — Barnard (1969)

Where A = a combination of the A/16 and A/68

B = a combination of the A/16 and A/3

C = a combination of the A/68 and A/16

D = a combination of the A/16, A/68 and A/3

Barnard (p. 286) found the most practical battery to use for predicting achievement in Mathematics, Physics, Principles of Electricity and Applied Mechanics was the A/16, A/3 and A/68 tests. The A/80 was used to predict achievement in Engineering Drawing.

Barnard (1969, p. 401) felt that better tests for predicting success in physics and mechanical insight could be developed in order to increase the validity of the battery he used. Since the publication of his study, a new factor has made the A/16 inappropriate in selecting for mathematical ability, namely the change in school's mathematics syllabi. This means that a new type of mathematical ability test is needed.

A survey of all male school pupils in the Cape Province who took mathematics and science in 1969 as a standard 10 subject, was conducted by Smit (1976). He found that those pupils who attended Technikons and passed their first year Diploma subjects had done on average slightly better at school on both the Coordination Test and Tool Test (Junior Aptitude Test Battery) than successful university students and unsuccessful Diploma students and university students. Unfortunately, no validation studies predicting academic success of first year engineering Diploma students have been done using the Coordination Test or the Tool Test.

Research work suggests that of the tests of specific ability, those which measure numerical or mathematical ability appear to be the best predictors of achievement at engineering colleges. Studies indicate that tests of spatial and form perception are useful predictors, while mechanical ability tests appear to predict academic success fairly well, especially in multiple correlations with the above mentioned tests and scholastic achievements.

Barnard's finding that the use of ability tests together with matriculation achievements improves the prediction of academic success concurs with Steyn and Lätti's (1974) findings, and the same approach will be used in the present study.

3.2.5 Research in prediction of engineering success using measures of scholastic achievement

Pierson (1947) found in a nine year study on 463 students at Utah University that average school marks have a more direct relationship with successful academic training than any single school subject. However, this study did not focus specifically on engineering courses, and research indicates that stress should be laid on achievement in mathematics when predicting engineering success.

In South Africa, De Vos et al (1972) used a "matriculation index" to predict success of first year engineers at Pretoria University. The matriculation index was obtained by adding the overall subject average to the mathematics mark and dividing by two. Records from 1957 to 1970 were used, and a correlation coefficient of r = 0,58 (significant at the 99,9% level) was found to exist between the "index" and first year engineering success. It was also found that students with a second class matriculation pass (less than 60% average) have an 8% probability of passing all first year engineering subjects on their first attempt, whilst those with first class passes (60% average or more) have a 44% probability of passing all subjects.

Steyn and Lätti (1974) conducted a study designed to predict first year engineering success at Pretoria University. They administered the Scientific Knowledge Test, the Gottschaldt Figure Test and the Mental Alertness Test to 282 first year engineering students at Pretoria University in 1971. The criteria used were the end of year marks obtained by the students and the following intercorrelation matrix was obtained: (See Table 3.6, p32)

Matriculation mathematics correlates between 0,55 and 0,67 with the criteria while the matriculation average correlated between 0,51 and 0,69. Similar results were obtained in 1970 when 235 engineering students at Pretoria University were tested. The correlations of matriculation mathematics with the criterion subjects ranged from 0,14 to 0,32 while the matriculation average symbol correlated with the criteria

TABLE 3.6

INTERCORRELATION MATRIX OF VARIOUS PREDICTORS AND FIRST YEAR ENGINEERS AT PRETORIA UNIVERSITY

N = 282	1	2	3	4	5	6	7	8	9	10	11
1. Scientific Knowledge Test	-										
2. Gottschaldt Figures	0,14	-									
3. Mental Alertness	0,38	0,32	-								
4. Matriculation Mathematics	0,28	0,23	0,38	-							
5. Matriculation Average	0,34	0,23	0,39	0,79	-						
6. Chemistry I	0,32	0,15	0,36	0,59	0,62	-					
7. Physics I	0,29	0,17	0,37	0,62	0,67	0,84	-				
8. Applied Mathematics	0,31	0,20	0,43	0,67	0,68	0,82	0,90	-			
9. Mathematics	0,28	0,16	0,35	0,62	0,65	0,85	0,94	0,90	-		
10. Machine Construction	0,27	0,28	0,36	0,55	0,51	0,60	0,68	0,74	0,66	-	
11. Final Average	0,32	0,21	0,41	0,67	0,69	0,90	0,96	0,95	0,95	0,79	-

(Steyn and Lätti,
1974, p19)

between 0,26 and 0,54. These results indicate the somewhat unstable predictive value of scholastic achievement. Steyn and Lätti (1974) used de Vos's "matriculation index" and found a correlation of 0,635 and 0,71 between the 1970 and 1971 first year engineers' marks and their matriculation results. In both cases, the addition of the psychological tests made a difference of approximately 0,04 in a multiple correlation with the criteria.

In a follow-up survey of all male matriculation students who took mathematics and science in the Cape Province in 1969, Smit (1976) found that of the first year students at Technikons, all those who obtained 70% or more for matriculation mathematics passed their first year Diploma course. Smit also found that the average matriculation science marks obtained by students who passed first year engineering at university was 73,7%, while those who failed had an average science mark of 60,4%. Those students who passed their first year engineering Diplomas obtained an average matriculation science mark of 55,5% as opposed to 51,7% for those who failed. These findings indicate that a relationship does exist between matriculation science and mathematics and success in engineering studies.

In a study to validate a selection battery for university engineering students, van Tonder (1977) used as predictors a number of ability tests, a test of general intelligence and matriculation marks. He obtained a multiple correlation of $R \doteq 0,71$ between a weighted academic criterion of end of year marks, and a combination of : matriculation average alone, its products with mathematics and science, and the product of mathematics and science.

It is concluded from these findings that scholastic achievement remains the best single predictor of first year engineering success at university, while psychological tests make a small but unique contribution in prediction studies. Little is known about the relationship between scholastic achievement and success at a Technikon. It should be borne in mind when using school marks as predictors that standards vary from school to school and within the same school from year to year. Another factor to bear in mind is that individuals with brilliant school records often sacrifice certain phases of their personality and general development, which may lead to various types of behavioural problems.

3.3 Non-Intellectual Factors as Predictors of Engineering Success

3.3.1 Research in predicting engineering success using interest questionnaires

Möller (1965) used the Kuder Preference Record to establish whether any correlation existed between interests and academic achievement amongst university engineering students. His study revealed significant correlation coefficients of the order of 0,31 between the Computational interest field and mathematics and applied mathematics. He also reported a negative correlation between Mechanical interest and most of the engineering subjects. However, empirical studies by Strong (1945), Gouws (1966) and van Tonder (1969) indicated that interest as a variable was not a valid predictor of academic success in their specific studies; not because its role is unimportant but because the relationships between different interests and a criterion are usually complex. For example, an interest may be shown in medicine because the medical profession has high earning possibilities and status, without there being any knowledge of the intrinsic work involved.

Garbers and Van Aarde (1974) found in an analysis of 8 214 school pupils' reasons for choosing a career, that interest was the strongest consideration, but Garbers and Faure (1972) found that measures of interest in a study orientation are poor predictors of academic success.

Achievement orientated assessment of specific interests could be a method of improving psychological assessment of the role of interests. Statistical prediction of success from interests depends on the removal of contaminating effects.

3.3.2 Research in predicting engineering success using personality measures

Much conflicting evidence can be quoted on this topic. Steyn (1972) administered the South African Personality Questionnaire (designed to measure five dimensions of personality) and Cattell's 16PF Questionnaire to first year engineering students and found that not one of the 21 possible predictors showed a significant correlation with the academic criterion. Eysenck (1947) has suggested that attempted measurement of personality factors for students selection be discontinued.

3.4 Biographical Factors as Predictors of Engineering Success

Garbers and van Aarde (1974) found in a large scale study of White matriculant pupils that as the educational standard of the parent drops, so a greater likelihood exists for their children to be employed as clerks, technicians, artisans and policemen. Thus it would appear that pupils whose parents are less educated tend towards more practical career orientations.

Garbers and van Aarde (1974) have suggested that the type of school attended together with the home background both play a most important role in career success. Their study suggests that the typical pupil technician has a family background characterised by fairly low scholastic achievement level. Smit (1976) analysed data obtained from 314 Diploma technicians who wrote examinations during their first year of study and found that of the 52 who had come from technical high schools, 75% passed, while of the 262 who had come from other schools, 77% passed. This finding indicates that school type makes very little difference to the pass rate. However, de Vos et al (1972) found a statistically significant difference in the pass rates of first year engineering students at Pretoria University from various school types. The following are the percentages of students who passed all first year subjects:

a) 33,7% from Afrikaans academic urban schools
b) 31.3% from Afrikaans academic rural schools
c) 23,3% from English academic urban schools
d) 28,8% from technical and commercial high schools
e) 18,2% from technical colleges, and
f) 29% from other schools.

However, the latter findings are drawn from a small and non-representative proportion of South African first year students. The apparently contradictory findings of Smit (1976) and de Vos et al (1972) will be investigated in the present study, and an analysis of the results obtained by the experimental group will be done to see whether school type makes any difference to the pass rate. Many other biographical and environmental factors (e.g. work experience, best and least liked subjects, number of failures at school) have been taken into account in attempting to predict academic success, but most of these factors co-vary either with scholastic achievement or with intelligence. Thus far, improved measures in the prediction of academic success using such factors have been so small or unstable as to be not worth using.

3.5 Summary

Most researchers into the field of predicting engineering success agree that prerequisites for training an engineer are:

i) Mathematical ability
ii) Good spatial perception
iii) Ability to understand mechanical principles
iv) Ability to learn relevant material

One of the most successful predictor batteries used to select engineering students is the "Pre-Engineering Inventory" (Vaughn, 1947/8). In this battery the General Mathematical Ability and the Comprehension of Scientific Materials Tests proved to be the best predictors.

The literature indicates a positive relationship between measures of general intelligence and academic success, while scholastic achievement (especially weighted combinations of matriculation marks for mathematics and physical science) appears to be the best predictor. Some studies have found that specific interests are positively correlated with academic success, but the results are inconclusive and their contribution towards the prediction of performance is small.

Personality assessment in predicting academic success shows little promise at this stage.

Biographical information is useful in indicating broad trends (eg. school type and parents education often correlate significantly with success), but selection techniques of applicants for institutes of advanced education should focus on applicant's extant abilities rather than historical background information, or else be seen as perpetuating socio-economic differences.

A suggestion that should be followed up (Barnard, 1969) in the selection of engineering technicians is that a non-academic criterion of success be used, since the engineering technician also undergoes practical training. Another factor that has been high-lighted is the generally high correlation of mathematical ability with academic success, which points to the need for developing an ability test based on the new South African syllabus for mathematics.

CHAPTER FOUR

4. DESCRIPTION OF THE SAMPLES, PREDICTORS AND CRITERIA

4.1 Sample

The experimental sample consisted of 359 first term engineering technicians enrolled for the Diploma courses in civil, mechanical and electrical (light current) engineering. This sample was obtained by testing all the first term students in the abovementioned engineering fields at the beginning of three consecutive terms between September 1975 and May 1976 (i.e. intakes 1 to 3). The total group of first term students was analysed and the following facts emerged:

i) Mean age was 20,2 years;

ii) Mean work experience was between six and twelve months;

iii) Socio-economic background of the experimental group could be broadly classified as predominantly lower middle class;

iv) Most of the group came from urban academic schools - only 19,4 per cent (69) came from technical schools;

v) Almost a third (108) of the students had failed at least once at school;

vi) Enrolments for the electrical engineering Diploma course constituted almost half of the experimental group (151).

TABLE 4.1

BREAKDOWN OF FIRST TERM STUDENTS INTO SPECIALIZATION GROUPS AND HOME LANGUAGE.

Home Language	Specialization Groups				
	Mechanical	Electrical	Civil	Other	Total
English	51	76	60	14	201
Afrikaans	22	53	18	5	98
Other	19	22	9	10	60
Total	92	151	87	29	359

It was decided to use only civil, mechanical and electrical Diploma students in the validation study because a large percentage of all engineering technicians enrol in one of these three specialization fields. There is also a fairly large overlap in the first term subjects to be done in the three specialization courses - three out of five subjects are common to the different syllabi.
A sample of final term students who were enrolled for the same specialization fields was tested simultaneously with the experimental sample in order to make a comparison between the predictor variables of first and final term students. All students were tested in either English or Afrikaans.

TABLE 4.2

TEST LANGUAGE OF ALL STUDENTS TESTED IN EACH INTAKE

Test Language and Term	Intake I (Sept.1975)	Intake 2 (Jan.1976)	Intake 3 (May 1976)	Total
1st Term English	86	99	84	269
1st Term Afrikaans	31	34	25	90
Final Term English	48	19	32	99
Final Term Afrikaans	3	3	17	23

It was observed that certain foreign language students experienced difficulty with the verbal tests, and it was therefore decided that home language would be used to classify students into homogeneous groups. Of the 359 first year students tested, only 299 spoke either English or Afrikaans at home, and a further 109 sets of information were found to be unsuitable for multiple regression analyses because of incomplete predictor or criterion information.

The experimental group was broken down into a number of smaller more homogeneous groups (namely into English and Afrikaans specialization groups) to check for significant differences in criterion and predictor material. The number of Afrikaans students was too low to justify the computation of separate validations for individual specialization group subjects.

The groups were used for the following purposes: (Table 4.3, p41).

4.2 The Predictors

The predictors of academic success in this study were tests of general and specific intellectual abilities, biographical information (which included scholastic achievements) and an interest questionnaire to check its suitability for counselling.

4.2.1 Scholastic performance

As mentioned in Chapter 3, most researchers have found that school performance yields the best correlations with academic success, although the majority of such studies have predicted short term success of university students as opposed to Technicon students. In the present study, the matriculation marks for mathematics, science, English and Afrikaans have been used as possible predictors of academic success, as these are the most common matriculation subjects for technical students.

4.2.2 Tests of specific abilities and general intelligence

4.2.2.1 Description of tests used

Many different correlations between ability tests and academic success have been reported by researchers. The most effective ability tests in selecting engineering students are usually the tests of mathematical ability, spatial ability and comprehension of scientific material. The present study used the Blox Test, the Deductive Reasoning Ability Test, the Gottschaldt Figures Test and the General Science Test which is comprised of the Scientific Knowledge and Technical Reading Comprehension Tests. No suitable test of mathematical ability was available for inclusion in the predictor battery.

Segel (in Barnard, 1969, p178) reports that general intelligence has a higher correlation with academic achievement (median correlation = 0,44) than any test of specific ability

TABLE 4.3

SIZE AND EXPERIMENTAL FUNCTION OF GROUPS

Group	N	Function of Group
All First Term Students	359	To compare predictor variables with those of all final term students
First Term, English, Civil	53	To validate predictors against all course subjects
First Term, English, Mechanical	42	To validate predictors against all course subjects
First Term, English, Electrical	68	To validate predictors against all course subjects
First Term, English	163	1. To validate predictors against the three common course subjects, i.e. Mathematics, General Studies and Engineering Drawing, as individual criteria.
		2. To validate predictors against the average of the common course subjects.
		3. To validate predictors against the number of courses passed.
First Term, Afrikaans	98	1. To validate predictors against the three common course subjects, i.e. Mathematics, General Studies and Engineering Drawing, as individual criteria.
		2. To validate predictors against the average of the common course subjects
First Term, Afrikaans Intake Groups 2 and 3	50	1. To validate predictors including the Gottschaldt Figures Test against the common course subjects.
		2. To validate predictors against the number of courses passed
All Final Term Students	120	To compare predictor variables with those of all first term students.

(median correlation = 0,37). This is probably because satisfactory academic performance in higher education requires a number of abilities. While no one test of a specific ability samples behaviour as widely as a test of general intelligence, these specific ability tests may be important and can in the right combination give the best prediction. Barnard (1969) found a very low correlation between general intelligence (as measured by the Mental Alertness test) and first term results of engineering technicians. Nonetheless, the Mental Alertness test has been included in the battery, since it appears to have a considerable amount in common with academic course material. A fuller description of the tests mentioned above follows:

A. The Blox Test

This is a test of perceptual ability and has 45 questions to be answered in 30 minutes. On each page of the question booklet five sets of cubes are presented. The number of blocks in each set varies between two and six, and they are arranged together to form various configurations. The subject has to identify from a number of possible answers which alternative set of blocks, seen from a different viewpoint, corresponds to the question item. Thus the subject must manipulate mental images of geometric patterns. This means that aspects of spatial reasoning, spatial orientation and visualization are included in the test.

B. The Gottschaldt Figures Test

This is an embedded figure test which measures analytic perceptual ability. The version used by the NIPR consists of 45 complex figures, each of which contains one of five simpler key figures. The subject is given twenty minutes to do the test. His task is to identify which key figure is contained in each complex figure. The test requires the ability to extract the embedded figure from the complex figure without being distracted by the overall gestalt. According to Hall *et al* (1970), the Gottschaldt test is related to the personality dimension of autonomy: the autonomous person is described as one who is:..."capable of structuring ambiguous situations into clearly definable, articulated parts" and can "reconcile these articulated parts with his inner frame of reference .." (p 41). The Gottschaldt Test is also thought to be related to field dependence and independence, and Herholdt (1972) has suggested that field independence is in turn related to creativity. However, it should be noted that the Gottschaldt Test is not a pure measure of this personality factor.

C. The General Science Test

This test is designed to measure technical and scientific knowledge. It is a type of achievement test that measures sophistication in the technical and scientific field. The candidate who possesses a sound knowledge of technical and scientific concepts will have a better chance of success in learning and gaining higher levels of insight and knowledge in this field. The test is useful in predicting the degree of success an applicant entering a technical/scientific field is likely to have. The test consists of two subtests, namely, the Scientific Knowledge Test and the Technical Reading Comprehension Test.

a) The Scientific Knowledge Test contains 35 multiple choice items and must be completed within 20 minutes.

b) The Technical Reading Comprehension Test consists of ten paragraphs of material of a technical nature followed by multiple choice questions.

To obtain correct answers on this test requires a thorough understanding of the content of the paragraphs, which includes technical/scientific concepts. Transformation of the information is necessary, requiring synthesizing and paraphrasing abilities, all within the context of a language medium. Testing time is 35 minutes and the test is suitable for persons with at least twelve years of formal schooling.

D. The Deductive Reasoning Ability Test (DRAT)

(Intermediate Level)

This test is designed to measure the ability to make valid inferences from given information and to draw valid conclusions from premises or propositions within the framework of formal deductive logic. The test consists of 30 questions to be answered in 40 minutes, and is presented in a multiple choice format.

E. The Mental Alertness Test (High Level)

This is a test of general intelligence in which the questions posed are both verbal and non-verbal. It includes reasoning tasks in the form of verbal analogies, classification of abstract concepts, and figure and letter series. The test consists of 42 questions, has a time limit of 45 minutes and is presented in a multiple choice format.

4.2.2.2 Reliabilities of tests used

Reliabilities for all the tests used have been calculated before, but not always on appropriate norm groups. Only estimates of the relaibility of each test could be made since individual items were not coded. The Kuder Richardson 21 formula indicates the lower limit of the estimated reliability, and the Tucker correction gives a more accurate estimation of reliability. The reliabilities obtained are regarded as being acceptable (see Tables 4.4 and 4.5). Considering that the group tested is restricted in terms of abilities (brighter scholars usually attend university while those not passing mathematics and science in the matriculation examination are not usually accepted at a Technikon, the reliability coefficients are fairly high.

4.2.3 Interest questionnaire

The interest questionnaire administered to the engineering technicians in the present study was the Rothwell-Miller Interest Blank. Although research indicates that no correlations are found between interest and academic success (Strong, 1945; Gouws, 1966; van Tonder, 1969), this finding may be less relevant to engineering technicians since their training includes practical work which may be closely associated with hobbies.

TABLE 4.4

MEANS, STANDARD DEVIATIONS, COEFFICIENTS OF SKEWNESS AND KURTOSIS, OBSERVED RANGES AND RELIABILITIES OF AFRIKAANS GROUP.

Tests	Mean	S D	Sk.	Kt.	Range Min	Max	Reliability KR21	KR 21 (Tucker)
Mental Alertness	25,7	5,3	-0,43	0,31	11	37	0,68	0,80
Blox	32,8	4,6	-0,22	0,17	21	43	0,59	0,78
DRAT	13,8	4,7	0,32	-0,07	5	26	0,74	0,84
Scientific Knowledge	17,6	4,9	0,53	-0,59	10	29	0,68	0,79
Technical Reading	18,6	3,8	-0,14	-0,68	10	25	0,86	0,91
Gottschaldt	21,6	8,5	0,57	-0,63	8	39	0,86	0,92

TABLE 4.5

MEANS, STANDARD DEVIATIONS, COEFFICIENTS OF SKEWNESS AND KURTOSIS, OBSERVED RANGES AND RELIABILITIES OF ENGLISH GROUP

Tests	Mean	S D	Sk.	Kt.	Range Min	Max	Reliability KR21	KR 21 (Tucker)
Mental Alertness	25,6	5,5	-0,33	-0,32	11	39	0,69	0,81
Blox	34,6	4,2	-0,13	-0,62	25	44	0,56	0,77
DRAT	17,4	5,1	-0,24	-0,38	6	28	0,75	0,85
Scientific Knowledge	21,7	4,6	-0,34	0,02	8	31	0,66	0,79
Technical Reading	19,8	4,9	-0,25	-0,12	6	30	0,77	0,87
Gottschaldt	20,8	9,3	0,37	-0,75	3	42	0,88	0,93

The basic rationale of the Rothwell-Miller inventory is that people hold stereotyped conceptions about the nature of occupations, and that they base their choice of occupation on these stereotyped concepts. Although such concepts are often based on spectacular aspects of the job, the authors of the test feel that the important point is not the accuracy of the stereotype but.....

> "the fact that it does exist and strongly influences a person's conception of the occupation"
> (Miller, 1968)

To complete the Rothwell-Miller inventory the subject has to rank in order of preference nine sets of twelve different job titles each of which job fits one of the following broad interest fields:

Outdoors, Mechanical, Computation, Science, Persuasive, Aesthetic, Literary, Musical, Social, Science, Clerical, Practical or Medical. There is no time limit for filling out the questionnaire.

4.2.4 General biographical information

A comprehensive biographical questionnaire was filled in by all students tested in order to identify common background factors and to check for possible predictors of academic success. It has been reported (Garbers et al, 1974) that:

i) Some relationship exists between parents' education (reflected in parental occupation) and academic results; and

ii) The type of school (i.e. academic, commercial, technical or agricultural) attended may be an important factor in predicting academic success.

Other factors investigated in this study include standards failed at school, previous training, work experience, and attendance of the "pre-technician" course which is offered by the engineering faculties to applicants to the courses if they have failed or not completed matriculation mathematics or science, so that the faculty has some means of judging their abilities in these fields. A full copy of the questionnaire is included in the Appendix (A. 35) and analyses of the differences occurring between groups on predictor information can be found in the following chapter.

4.3 Criterion Information

The course content offered at Technikons is chosen within the limits of a number of subjects recommended by the Department of National Education. The Council of each Technikon considers specific demands for subjects from employers within the surrounding business environment, and if a large enough demand for a certain subject exists the syllabus is changed to accommodate the need. Thus subjects offered by the various Technikons around South Africa reflect to some extent the particular needs of the industrial environment of the individual Technikons.
The full syllabi of the three specialization courses offered at the Witwatersrand Technikon are as in Table 4.6.
In the present study, the marks obtained by the experimental group after completing Part 1 of their respective courses were used as the academic criteria. These marks are obtained from two term tests, which are one-and-a-half hour papers set by the teaching staff and moderated by senior lecturers in the departments, and one end-of-term examination, which is a three hour paper except in the case of engineering drawing which is a four hour paper. These examinations are also set and moderated by the teaching staff, and count for 75 per cent of the final mark, while the two mid-term tests contribute 25 per cent of the final mark.

A brief description of the requirements for each of the Diploma courses follows. (A fuller description of course subject matter is included in the Appendix A.13 to A. 20)

4.3.1 The electrical engineering diploma (light current)

This is a four year "sandwich" course, two years of which are spent studying either full time or on a block release system

TABLE 4.6

SYLLABI OF ELECTRICAL (L/C), MECHANICAL AND CIVIL ENGINEERING DIPLOMA COURSES.

ELECTRICAL ENGINEERING (light current)	MECHANICAL ENGINEERING	CIVIL ENGINEERING
Part 1	Part 1	Part 1
Mathematics T111	Mathematics T111	Mathematics T111
Principles of Electricity T111	Applied Mechanics T111	Applied Mechanics T111
Applied Technology T111 or Applied Mechanics T111	Engineering Drawing T111	Engineering Drawing T111
Engineering Drawing T111	Principles of Electricity T111	Electrotechnology T111
General Studies T111	General Studies T111	General Studies T111
Part 2	Part 2	Part 2
Mathematics T221	Physics T111	Physics T111
Physics T111	Workshop Technology T111	Workshop Technology T111
Electronics T211	Mathematics T221	Geology T211
Workshop Technology (L.C.)T111	Engineering Drawing T221	Surveying T211
General Studies T221	General Studies T221	

TABLE 4.6 (continued)

ELECTRICAL ENGINEERING (lignt current)	MECHANICAL ENGINEERING	CIVIL ENGINEERING
Part 3 Physics T221 Principles of Electricity T221 Communication Electronics T221	Part 3 Principles of Electricity T221 Engineering Metallurgy T221 Applied Mechanics T221	Part 3 Mathematics T221 Applied Mechanics T221 Building and Civil Engineering Construction T 212 Civil Engineering Drawing T212 General Studies T221
Part 4 Automatic Control T311 Electronics T321 Communication Electronics T321 Mathematics T331	Part 4 Strength of Materials T311 Mechanics of Machines T311 Machine Design T311 Applied Thermodynamics T311	Part 4 Theory of Structures T311 Structural Design T312 Hydraulics T311 Building and Civil Engineering Construction T322 General Studies T331

TABLE 4.6 (continued)

ELECTRICAL ENGINEERING (light current)	MECHANICAL ENGINEERING	CIVIL ENGINEERING
Part 5	Part 5	Part 5
Radio Communication T411	Mathematics T331	Civil Engineering Quantities, Specifications & Estimating T412
Electrical Technology T311	Hydraulics T311	Soil Mechanics T311
Industrial Electronics T411	Electrotechnology T411	Mathematics T331
Television T311 or Microwave Techniques T311	Strength of Materials T421	Construction Management T411
Digital Techniques T311	General Studies T331	
General Studies T331		Surveying T321
Part 6	Part 6	Part 6
Television T421 or Microwave Techniques T421	Hydraulics T421	Theory of Structures T421
	Mechanics of Machines T421	Structural Design T421
Digital Techniques T421	Machine Design T421	Hydraulics T421 or Mathematics T441
Audio Engineering T411 or Automatic Control T421	Applied Thermodynamics T421	
Electronic Measurements T421		Road Construction and Design T411

at the Technikon and the remainder in gaining practical experience in industry. The following subjects, requiring a 50 per cent pass mark, are compulsory in the first term.

Mathematics T111

This includes the study of Algebra and Trigonometry,Differential and Integral Calculus and Complex Numbers.

General Studies T111

This includes communication between different organisations and between individuals and organisations (letters, reports and verbal media).

Engineering Drawing T111

This includes Freehand Sketching, Construction, Projections, (Auxilliary and Isometric), Intersections, Machine Drawing and Vectors.

Principles of Electricity T111

This includes the study of the Electric Current, the Electric Circuit, Magnetism (the Magnetic Field, Electromagnetic Induction, Magnetic Circuits), Electrostatics, Alternating Currents and Measuring Instruments.

Applied Technology T111(L.C.)

This includes the study of Passive Components (Resistors, Coils, Transformers, Capacitators), Constructional Components, Electro-Mechanical Devices, Batteries and Accumulators and Thermionic Valves.

OR

Applied Mechanics T111

This includes General Definitions, Vectors, Statics, Non-Current Forces, Forces in Frameworks, Centre of Gravity, Friction, Simple Machines, Elasticity, Dynamics, Work, Energy and Power, and Angular Motion.

4.3.2 The mechanical engineering diploma

This is a four year "sandwich" course completed in the same way as the electrical engineering Diploma (above) except that students may not complete their academic studies on a full time basis (as they can do in the electrical light current Diploma course). The following subjects are compulsory in the first term of study.

Mathematics T111

As under Electrical Engineering Diploma on previous page.

General Studies T111: as above

Engineering Drawing T111: as above

Applied Mechanics T111: as above

Workshop Technology T111

This includes the study of Safety Precautions in a Workshop, the Purpose of Hand Tools, Measurement and Marking Out, Screw Threads, Joining Materials, Sheet Metal Work and the Purpose of certain Machine Tools.

4.3.3 The civil engineering diploma

This is also a four year "sandwich" course, completed in the same way as the mechanical Diploma.

Compulsory first term subjects are:

Mathematics T111: Described under electrical engineering

General Studies T111: as above

Engineering Drawing T111 : as above

Applied Mechanics T111 : as above

Electrotechnology (Civil) T111

This includes a General Introduction, Magnetism, Alternating Currents, (Induction Motors, Transformers,) Reticulation and Construction.

4.4 Choice of an Academic Criterion

A number of measures of academic success are possible in this study, but the need for a practical measure which is administratively economical is of paramount importance. It is not considered practical to make separate predictions for individual course subjects, since they cannot be as efficiently predicted as the composite criteria (See Table 6.3) and such a procedure would require much administration time. Two measures of an academic criterion have been considered in the present study:

a) the average mark obtained for the three common-course subjects (Mathematics, General Studies and Engineering Drawing), or

b) the number of courses passed.

One disadvantage of using (a) is that an arithmetical mean is calculated from the actual marks obtained, and an arbituary mark (in this case one per cent) had to be assigned to students who dropped courses; this could result in cases in which students who obtain average passes for three subjects and who drop two common-course subjects appear in terms of their average as total failures, whereas those who do not drop subjects but actually pass only one subject may appear more successful than those who have passed three subjects.

Another disadvantage of using the common-course-average is that it precludes the utilization of all criterion information, since the averages of the non-common course subjects cannot be meaningfully compared. However, it was found that course average correlated between 0,91 to 0,95 with the common-course-average for the three English specialization groups; it therefore appears that prediction of success of the three common-course subjects will to a large extent cover the prediction of success of the non-common course subjects as well. Thus the exclusion of all the college courses in the criterion apparently does not represent a serious loss of information. Since both criteria represent meaningful and obvious measures of academic success, and because correlations between common-course-average and courses passed range from 0,80 to 0,88, indicating a large overlap between them, it has been decided to utilize whichever criterion yields the highest correlation with the predictors.

CHAPTER FIVE

5. COMPARISON OF SAMPLE SUB-GROUPS

5.1 Introduction

The predictor information was obtained by testing three consecutive intakes of first term students from three engineering fields (specializations) at the Witwatersrand Technikon (see Table 4.1); the students were mainly English (N=163) or Afrikaans (N=98) speaking.

In order to optimize the effectiveness of the prediction exercise, comparisons were made to establish how best to combine the various sub-groups into the largest possible homogeneous grouping. Variance in the predictor information obtained from

a) the three specialization groups,
b) the three intake groups, and
c) the two main language groups (English and Afrikaans)

was analysed for the functions specified in Table 4.3. Technikon examination results of students from academic and technical schools were compared, and all first term students were compared with final term students in order to assess whether any observable "natural selection" of abilities had occurred, thereby indicating which predictors could be useful for selection of "the fittest".

5.2 Comparison of First (T1) and Final (T6) Term Engineering Students.

In comparing all T1 and T6 students tested, the assumption is made that the two groups come from the same population. Any significant differences on the compared variables can be considered to be due to either a natural selection process based on course demands, or else to a change in the psychological structure of students due to course inputs. Significant differences found in comparing T1 and T6 students will be considered for inclusion as predictors in the multiple correlations.

Significant differences found between the two groups are described under Background Information and Test Scores, and the relevant statistical information is presented in Table 5.1

A. <u>Background Information</u>

a) <u>Family size</u> - T6 students had significantly fewer siblings than T1 students. This may indicate that children from smaller families received more social stimulation from their parents, which improves their academic achievement.

b) <u>School standards failed</u> - relatively fewer T6 students failed standards at school than T1 students.

c) <u>Least liked school subjects</u> - relatively more T6 students disliked mathematics and science than T1 students. However the response from the T6 students may have been affected by their experiences with mathematics at the Technikon.

d) <u>Incomplete training</u> - significantly more T6 students had <u>not</u> completed earlier post-school training. This finding could be taken to indicate that broader experience helps students to define their vocational interests more clearly; the experience of failure in other fields may also result in more determination and energy being channelled into the reduced number of vocational options.

e) <u>Relevant training</u> - a significantly larger proportion of T6 students had received relevant training in comparison to T1 students. This is largely accounted for by the T6 students' greater number of practical work periods, in which opportunities to obtain relevant training exists.

f) <u>Matriculation marks</u> of T6 students were significantly higher in mathematics, science and Afrikaans, pointing to the importance of these marks as predictors of academic success.

B. Test Scores

As was expected the T6 group fared generally better than the T1 group on the battery of tests administered. The big differences noted on the Technical Reading Comprehension and Scientific Knowledge Tests can be partly accounted for by the fact that the engineering courses teach skills which should improve test performance on these two tests since they measure learned responses rather than general aptitude. However, the Mental Alertness and Blox Tests are thought to measure attributes which are fairly stable over time; it therefore seems most likely that the significant differences found to exist between T1 and T6 students on the latter two tests is due to "natural selection" rather than acquired skills. This finding also suggests that those students with low general intelligence and poor perceptual skills will not complete the course.

No significant difference was found between the two groups on the DRAT, suggesting that the Deductive Reasoning Ability Test is measuring an ability which is not very useful in discriminating between successful and unsuccessful engineering Technicians.

C. Summary

The comparison between the T1 and T6 students was made in order to establish which variables discriminated between the two groups, with a view to using them as predictors of success for the T1 students and to gain some insight into the reasons for students dropping out of the courses.

However, not all the variables which were found to differ significantly between the two groups will be considered for use as predictors, since it is felt that selection decisions should be made in terms of existing abilities rather than in terms of irreversible background factors such as family size. Unstable predictors such as preferences for subjects will also be excluded because of the lack of control over the reliability of responses.

TABLE 5.1

SIGNIFICANT DIFFERENCES BETWEEN FIRST AND FINAL TERM STUDENTS

Variables	First Term Students			Final Term Students			Significance Levels
	Number	Total Group	Percentage	Number	Total Group	Percentage	Chi-Square Test
Students failing school standards	108	358	30	24	121	20	$p<0,05$
Disliked science and mathematics	82	338	24	42	113	37	$p<0,05$
Incomplete training	20	355	6	34	122	28	$p<0,001$
Relevant Training	84	356	24	50	121	41	$p<0,001$
	Mean		SD	Mean		SD	t Test (Comparing group means)
Family size (siblings)	3,38		1,27	3,04		1,27	$p=0,01$
Matriculation mathematics*	4,99		1,10	5,33		1,14	$p=0,01$
Matriculation science*	5,14		1,07	5,41		0,97	$p<0,05$
Matriculation Afrikaans*	4,40		0,89	4,68		0,99	$p=0,01$
Mental Alertness	25,09		5,75	26,35		5,15	$p<0,05$
Blox	33,95		4,56	35,84		4,46	$p<0,001$
Scientific Knowledge	19,83		5,32	22,80		5,15	$p<0,001$
Technical Reading Comprehension	18,95		5,16	21,36		5,36	$p<0,001$

*Matriculation marks expressed in tens (eg 60 to 69% = 6)

The significant differences between the two groups in the number of standards failed and the matriculation marks point to the use of these variables as predictors of success. Similarly, the Mental Alertness, Blox, Technical Reading Comprehension and Scientific Knowledge Tests will be investigated as predictors of first term success.

5.3 Comparison of Specialization Groups

This comparison was made in order to establish whether any significant differences existed between the first-term mechanical, civil or electrical groups, so that decisions on whether or not to combine the groups for correlation and regression analyses could be made.

Significant differences found between the specialization groups are described under Background Information, Test Scores and Technikon Examination Results, and the relevant statistical information is summarized in Table 5.2 (p61).

A. Background Information

The only noteworthy differences between the specialization groups were:

a) Relatively more electrical students had no relevant experience compared to students in the other groups;

b) The mean Afrikaans matriculation marks obtained by students enrolled for the civil course were significantly lower than the means of the other specialization groups.

B. Test Scores

The only test which discriminated significantly between the three specialization groups was the Technical Reading Comprehension Test, on which the electrical group obtained the highest mean score.

C. College Examination Results

No significant differences were found between the three specialization groups when comparing the end of term examination marks obtained for the three common-course subjects (i.e. General Studies, Engineering Drawing and Mathematics). Comparison of the number of courses passed also revealed that no significant differences existed between specialization groups (see Table 5.2, p61).

D. Conclusion

Approximately fifty variables were compared and if the assumption is made that they are independent observations, one would expect to find approximately 2,5 significant differences occurring at the p=0,05 level due to chance factors alone. The few significant differences found between the specialization groups suggest that there are no differences between the groups and that they can thus be combined in predicting success of the academic criterion.

5.4 Comparison of the Three Intake Groups

The three different intakes were tested over a one-year period in order to make the sample representative of an annual intake of students from the Witwatersrand Technikon. The assumption is made that there will not be large differences from year to year in the type of person attracted to the Technikon, although the individual intakes during the year may show differences. Intake 1 was tested in September 1975, intake 2 in January 1976 and intake 3 in June 1976. Significant differences found between the intake groups are described below, and Table 5.3 summarizes the relevant statistical information.

A. Background Information

Analyses of the information revealed that significant differences existed between the intakes on the following variables:

a) Intake 1 students had the greatest amount of general work experience;

TABLE 5.2

SIGNIFICANT DIFFERENCES BETWEEN THE THREE SPECIALIZATION GROUPS

Variables	Mechanical Group			Electrical Group			Civil Group			Significance Level
	Number	Total Group	Percentage	Number	Total Group	Percentage	Number	Total Group	Percentage	Chi-Square Test
No relevant work	40	94	43	90	149	60	30	92	33	p 0,001
	Mean	SD		Mean	SD		Mean	SD		t Test (Comparing group means)
Matriculation Afrikaans*	4,54	0,89		4,46	0,85		4,20	0,95		p 0,05
Technical Reading Comprehension	18,05	5,59		19,68	4,89		18,69	4,94		p=0,05

* Matriculation marks expressed in tens.

TABLE 5.3

SIGNIFICANT DIFFERENCES FOUND BETWEEN THE THREE INTAKE GROUPS

Variables	Intake 1			Intake 2			Intake 3			Significance Level
	Number	Total Group	Per cent-age	Number	Total Group	Per cent-age	Number	Total Group	Per cent-age	Chi-Square Test
Relevant work experience	88	115	77	43	131	33	61	110	56	$p < 0{,}001$
Electrical Diploma studies	40	109	37	68	132	52	55	110	50	$p < 0{,}01$
Pre-Technician enrol-ments	19	112	17	3	133	2	16	109	15	$p < 0{,}001$
Disliked mathematics and science most	70	102	69	9	133	7	3	103	3	$p < 0{,}001$

Variables	Intake 1 Mean	Intake 1 SD	Intake 2 Mean	Intake 2 SD	Intake 3 Mean	Intake 3 SD	t Test (Comparing group means)
Work experience (in 6 month units)	3,70	2,36	2,52	2,19	2,73	2,10	$p < 0{,}001$
Mean age	20,66	1,93	19,90	1,77	20,17	2,06	$p = 0{,}01$
Matriculation mathe-matics*	4,76	1,17	5,18	1,00	4,84	1,05	$p = 0{,}01$
Mental Alertness	24,60	5,73	26,41	5,69	24,01	5,58	$p < 0{,}01$
Engineering Drawing	55,43	21,81	49,41	20,20	47,88	18,50	$p = 0{,}01$

* Marks expressed in tens.

b) Most intake 1 students disliked both mathematics and science the most of all their school subjects;

c) More than half of the intakes 2 and 3 were composed of electrical Diploma students;

d) Proportionately fewer students in intake 2 had received relevant work experience, while students from intake 1 had received relatively the most relevant work experience;

e) The largest proportion of students enrolling for the pre-technician course came from intake 1, whereas the smallest proportion of students enrolled in the course came from intake 2;

f) The mean age of students in intake 2 was the lowest of the three intakes. This is not surprising since the January intake at a Technikon should contain more matriculants fresh from school, and this probably explains why students from this intake had less work experience;

g) Students from intake 2 obtained significantly better matriculation marks for mathematics. A possible reason for students with low marks enrolling later in the year is that they may have to complete supplementary matriculation examinations or the pre-technician course before commencing their Diploma studies.

B. Test Scores

Students in the intake 2 group obtained significantly better marks for the Mental Alertness Test. Assuming that the experimental sample is not a-typical, it appears that in an annual intake of engineering technicians, those who enter the Technikon in January have on average a higher general intelligence than those who enrol at later stages during the year (which corresponds with the finding that they obtain highest matriculation marks).

C. College Examination Results

Analysis of the common-course subjects, i.e. General Studies, Engineering Drawing and Mathematics, revealed a broad similarity between intake groups; the only significantly higher result was obtained by intake 1 in Engineering Drawing.

No differences were found between the intake groups in terms of the number of courses passed. Intake 2 students obtained the best marks for matriculation mathematics and the highest scores on the Mental Alertness Test, yet, did not obtain significantly better examination results; correlations will be calculated to establish the roles of the independent variables in the prediction of success.

(See Table 5.3, p62).

D. Conclusion

Once again approximately fifty variables were compared, and assuming the independence of observations, approximately 2,5 significant differences at the p=0,05 level could be expected to occur due to chance factors. The time lapse between intake groups was expected to affect variables which are related to time, thus work experience and age differences between groups are not surprising. Another experimental difficulty associated with the time lapse is the comparability of the academic criteria: it is difficult for teachers' evaluations not to be affected by group norms, (as opposed to evaluating students against independent course criteria), thus although the Witwatersrand Technikon strives for a fixed standard of course results, some differences between terms can be expected to occur.

It appears that the January intake receives a larger proportion of students who achieve better mathematics marks at school and also have a higher general intelligence than the other intake groups. The September intake has significantly more students who dislike mathematics and science and fail these subjects in their matriculation examinations; they are also the oldest and most work experienced. A possible explanation for more intake 3 students not failing their course could be that their greater work experience has defined their vocational interests more clearly, resulting in a higher level of motivation.

Although certain differences were found in the background variables sampled from the intake groups, these do not offer practical solutions as far as selection procedures for the different intakes through the year are concerned.

5.5 Comparison of English and Afrikaans First Term Students

Since a number of studies on South African samples have revealed consistent differences on psychometric tests between English and Afrikaans speakers (eg. Verster, 1973, Vermey, 1964), it was felt that such a comparison was necessary on the present sample. Significant differences are discussed below, and Table 5.4 gives more detailed statistical information.

A. Background Information

a) Afrikaans students obtained on average significantly higher matriculation averages than English students. However, this mark included first and second language results and since home language examinations are of a different standard to second language examinations, they should not be compared.

b) Although parents of English students had received more education, relatively more Afrikaans students' parents were classified as "professional and executive". This apparent anomaly may to some extent be due to confusion arising from the classification of such vague job titles as "manager" into the job categories of blue collar, white collar, and professional/executive. It is often difficult to know when certain broad ranging job designations should be classified as "professional and executive" or "white collar", and although level of education was used as a guide, uncertainty still existed in some cases;

c) Thirty per cent of the Afrikaans students were educated at <u>technical</u> high schools, while only thirteen percent of the English students came from such schools;

d) Most English students were educated in urban areas, whereas a large proportion of Afrikaans students were educated in rural areas;

e) A larger proportion of English students <u>failed school classes</u> once, compared to Afrikaans students;

f) Afrikaans students had more siblings than English students.

B Test Scores

No significant differences were found between English and Afrikaans students on the mental Alertness or Gottschaldt Figures Tests, but the English group did significantly better on the following:

a) the Blox Test;

b) the DRAT;

c) The Scientific Knowledge Test (SK);

d) the Technical Reading Comprehension Test (TRC);

Although this finding lends apparent support to other findings of significant differences occurring on psychometric tests between English and Afrikaans speaking population groups (eg. Verster, 1973), general conclusions should be drawn with great caution since the results are specific to the Witwatersrand Technikon and its student population, which in the case of the Afrikaans speaking students may be a-typical of Afrikaans speaking students attending Technikons.

C. College Examination Results

No significant differences were found between the means of the English and Afrikaans groups for any end-of-term examination marks, although the standard deviations of the English group were larger than the Afrikaans group for all subjects (see Table 5.4). This indicates that the Afrikaans group had a more uniformly average academic potential, whereas

TABLE 5.4

SIGNIFICANT DIFFERENCES FOUND BETWEEN THE TWO LANGUAGE GROUPS

Variables	English			Afrikaans			Significance Levels
	Number	Total Group	Percentage	Number	Total Group	Percentage	Chi-Square Test
Professional Parents	48	177	27	45	91	50	$p<0{,}001$
Attended Technical Schools	25	198	13	29	97	30	$p=0{,}001$
Educated in Rural Areas	33	201	16	43	96	45	$p<0{,}001$
Failed School once	61	201	30	12	97	12	$p<0{,}001$

/cont.....

TABLE 5.4

SIGNIFICANT DIFFERENCES FOUND BETWEEN THE TWO LANGUAGE GROUPS

Variables	English		Afrikaans		Significance Levels	
	Mean	SD	Mean	SD	t Test Comparing Means	SD's
Siblings	3,31	1,22	3,77	1,24	$p<0,01$	
Father-Units of Education	2,95	1,40	2,42	1,54	$p<0,01$	
Mother-Units of Education	2,46	1,20	2,06	1,30	$p<0,001$	
Matriculation Average*	4,90	0,75	5,17	0,60	$p<0,01$	
Blox Test	34,40	4,40	33,15	4,43	$p<0,05$	
DRAT	17,19	5,35	13,39	4,98	$p<0,001$	
SK Test	21,57	4,92	16,66	5,14	$p<0,001$	
TRC Test	19,99	5,25	17,49	4,42	$p<0,001$	
College Results						
General Studies	58,16	16,95	54,81	11,95		$p<0,001$
Mathematics	47,56	23,83	43,15	19,20		$p<0,05$
Engineering Drawing	50,46	21,01	51,44	16,92		$p<0,05$
Courses Passed	3,42	1,39	2,90	1,42	$p<0,05$	
Common Course Average	52,50	17,53	50,24	11,70		$p<0,001$

*Marks expressed in terms of tens

the English group had a range of low and fairly high academic potential. It was found that the Afrikaans group failed significantly more courses than the English group, and a significant difference between the variances of the common-course-average of the groups was found.

D. Conclusion

The difference between English and Afrikaans groups on the psychometric tests indicates the necessity for devising different selection formulae for each language group, especially in view of the fact that no significant differences were found in terms of the mean common-course-average examination results of the two language groups. Much predictive efficiency would be lost by combining the psychometrically heterogeneous data obtained from the two language groups.

5.6 Academic Schools compared to Technical Schools

Academic criteria of success of students from academic and technical high schools were compared to see whether differences in course marks were related to school type. No difference was found between students from the two school types in terms of the number of courses passed, but the mean of the common-course-average for students from academic schools was 54,8 (SD = 10,9) compared with 50,4 (SD = 10,4) for students from technical high schools, which represents a significant difference (p 0,05). However, since the classification of school type was made on a nominal scale of measurement, it could not be included as a variable in the correlation matrices, while the small number of students from technical schools made the further division of language groups into school types an impractical proposition. Thus, it is merely noted that such a difference has been found to exist between the mean common-course-average of students from the two school types.

CHAPTER SIX

6. ANALYSIS OF RESULTS

6.1 Introduction

In order to obtain maximum predictive efficiency of academic success, a number of regression equations were calculated from which the most suitable predictor battery was selected. Regression weights calculated for the selected predictors were simplified into prediction weights for practical application in assessing students.

However, it was first necessary to calculate intercorrelations of relevant predictor and criterion variables separately for the following first term groups:

- all Afrikaans students,
- all English students,
- each English speaking specialization group, and
- all Afrikaans students who completed the Gottschaldt Figures Test (i.e. intakes 2 and 3).

Separate correlations were calculated for each English specialization group in order to see if differences between the groups existed. This could not be done in the case of the Afrikaans group because of the small number of students.

The first set of intercorrelations (See Appendix, A.24 to A.29) were calculated using unequal numbers of variables in the matrices. However, the regression programme required equal numbers, thus after inspection of these results, another set of intercorrelation matrices were calculated using only complete protocols and the most promising predictors; the number of courses passed was included as a criterion of success.

The variables used in the first set of intercorrelation matrices were:

a) the scores obtained on the following tests:

   i) Mental Alertness Test (MA);
   ii) Blox Test;
   iii) Deductive Reasoning Ability Test (DRAT);

iv) Technical Reading Comprehension Test (TRC);
v) Gottschaldt Figures Test (GFT); and
vi) Scientific Knowledge Test (SK)

b) the following biographical information:

i) parents occupation (OCCUP);
ii) locality of school - either urban or rural (PLACE);
iii) number of times failed at school (FAIL);
iv) matriculation average (MAV);
v) individual matriculation results in mathematics, science, English and Afrikaans (MM, MS, ME, MAF);
vi) whether mathematics or science were the best or least liked subjects (BEST, LEAST);
vii) whether or not the student had enrolled for pre-technician courses (P TECH)

c) the academic criteria used for the combined groups were the common-course-average (COMCRSAV) and the individual common-course subjects, i.e.

i) General Studies (GENSTUD);
ii) Mathematics (MATHS);
iii) Engineering Drawing (ENGDRAW).

The average for all five courses (COURSAV) was included as a criterion for the specialization groups.
The functions of the intercorrelations calculated for each group are summarized in Table 4.3(p 41).

6.2 Intercorrelations

6.2.1 First term Afrikaans students

On examination of the matrix computed for all first term Afrikaans students (see Appendix, A.24) it was observed that the Gottschaldt Figures Test (GFT) which was administered only to Intakes 2 and 3 correlated the highest with the composite criterion (common-course-average). It was therefore decided not to use Intake 1 since the predictor battery was incomplete.

6.2.2 First term Afrikaans students (intakes 2 and 3 only)

A separate intercorrelation matrix was computed for only those Afrikaans students who completed the Gottschaldt Figures Test (see Appendix, A.25) and correlations of the order of 0,31 to 0,50 were found between individual common-course subjects and GFT; the correlation between the GFT and the common-course-average was 0,52. Unfortunately the sample size in this case was only 50.

6.2.3 First term English students

The correlation matrix (see Appendix, A.26) indicated that the psychological tests, with the exception of the GFT, generally correlated at a higher level with the composite criterion than any of the other predictors.

6.2.4 First term English specialization groups

The intercorrelation matrices calculated for the separate English specialization groups (see Appendix, A.27 to A.29) revealed inconsistent and low correlations between the common-course-average and attendance of the pre-technician course, dislike of school mathematics and science, parents' occupation, locality of school attended and the Gottschaldt Figures Test. The Mental Alertness Test was found to correlate highest with common-course-average in both the civil and electrical Diploma groups while in the case of the mechanical Diploma students, the best predictor of the composite criterion was the number of times failed at school

6.2.5 Intercorrelations excluding incomplete protocols

The new intercorrelation matrices which were calculated did not include the variables yielding low and inconsistent correlations with the criterion (some of which are discussed above) and also excluded was the matriculation average (since not all the students did the same subjects), and whether or not mathematics and science were the most enjoyed school subjects (as no control over the reliability of such responses can be maintained).

The number of courses passed (CRSPASSD) was included as a measure of academic success.

A English specialization groups

Inspection of the matrices for the English specialization groups (see Appendix, A.30 to A.32) revealed that the Mental Alertness and Scientific Knowledge Tests both correlated highest with the number of courses passed criterion in the case of the civil Diploma group, while matriculation Afrikaans and science correlated highest with the same criterion for mechanical and civil Diploma groups respectively (see Table 6.1). The highest correlations using common-course-average as the criterion of success were obtained with the number of standards failed (mechanical group) and the Mental Alertness (electrical and civil groups). The correlations with the criteria were generally not very high, in only a few cases being higher then 0,50, but this does not necessarily mean that the multiple correlations will be low; this depends on the independent contributions that the tests make to predicting the criteria.

TABLE 6.1

CORRELATIONS BETWEEN CRITERIA AND SELECTED PREDICTORS FOR THE ENGLISH SPECIALIZATION GROUPS

Variable	Common-Course-Average Criterion			Courses Passed Criterion		
	Mechanical (N=33)	Electrical (N=60)	Civil (N=47)	Mechanical (N=33)	Electrical (N=60)	Civil (N=47)
MA	0,23	0,28	0,54	0,09	0,22	0,57
Blox	0,17	0,18	0,33	0,13	0,07	0,32
DRAT	0,03	0,23	0,08	-0,01	0,14	0,25
SK	0,32	0,15	0,46	0,08	0,25	0,57
TRC	0,17	0,11	0,42	0,02	0,14	0,49
MM	-0,15	0,27	0,31	-0,21	0,15	0,21

cont......

TABLE 6.1 (continued)

Variable	Common-Course-Average Criterion			Courses Passed Criterion		
	Mechanical (N=33)	Electrical (N=60)	Civil (N=47)	Mechanical (N=33)	Electrical (N=60)	Civil (N=47)
MS	-0,00	0,25	0,31	-0,06	0,29	0,20
ME	0,07	0,00	0,19	-0,05	0,08	0,19
MAF	0,22	0,10	0,17	0,36	0,05	0,14
FAIL	-0,33	-0,17	0,04	-0,20	-0,19	0,06

(No significant differences were found between the correlations of corresponding specialization groups)

B Combined English group

The new intercorrelation matrix for the combined English group (see Appendix, A. 33) also revealed that the academic criteria of success correlated with the psychological tests at a higher level (with the exception of the DRAT) than all other variables; the Mental Alertness Test correlated highest with both academic criteria.

C Afrikaans group

In the case of the Afrikaans group, there were no cases of incomplete protocols for intakes 2 and 3; the correlations remained the same and the courses passed criterion was merely added to the matrix (see Appendix, A.34). The common-course-average criterion was found to correlate at 0,80 with the courses passed criterion.

6.3 Multiple Correlations

A number of multiple correlation coefficients were computed for the different groups in order to see which combinations of predictors yielded the highest correlations. A summary of these multiple correlations has been made below (Table 6.3 p76) and the following abbreviations used:

TABLE 6.2

ABBREVIATIONS OF PREDICTORS, GROUPS AND CRITERIA

Predictors	
Mental Alertness Test	- MA
Blox Test	- BLOX
Deductive Reasoning Test	- DRAT
Technical Reading Comprehension Test	- TRC
Gottschaldt Figures Test	- GFT
Scientific Knowledge Test	- SK
School Locality (urban/rural)	- PLACE
Preference for Mathematics and/or Science at school	- BEST
Dislike of Mathematics and/or Science at school	- LEAST
Number of Failures at School	- FAIL
Matriculation English	- ME
Matriculation Mathematics	- MM
Matriculation Science	- MS
Matriculation Afrikaans	- MAF
Groups	
First Year Afrikaans	- A1
First Year English	- E1
First Year English Electrical Specialization	- E1E
First Year English Mechanical Specialization	- E1M
First Year English Civil Specialization	- E1C
First Year Afrikaans who completed Gottschaldt Figures Test	- A1G
Criteria	
Average for all five college subjects	- CAV
Average for common-courses subjects	- COMCRSAV
Individual common-course subjects:	
i) General Studies	- GENSTUDS
ii) Mathematics	- MATHS
iii) Engineering Drawing	- ENGDRAW

TABLE 6.3

SUMMARY OF MULTIPLE CORRELATIONS FOR DIFFERENT GROUPS USING VARIOUS PREDICTOR COMBINATIONS

Group	Predictors	Criterion	N	R
E1M	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	CAV	42	0,667
E1E	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	CAV	68	0,616
E1C	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	CAV	53	0,743
E1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	GENSTUDS	163	0,477
E1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	MATHS	163	0,432
E1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	ENGDRAW	163	0,443
E1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	COMCRSAV	163	0,503
A1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	GENSTUDS	86	0,523
A1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	MATHS	86	0,506
A1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	ENGDRAW	86	0,531
A1	MA, BLOX, DRAT, SK, TRC, PLACE, FAIL, BEST, LEAST, MS, MM, ME, MAF	COMSRSAV	86	0,557

(Abbreviations in Table 6.2, p75)

/continued...

TABLE 6.3 (continued)

SUMMARY OF MULTIPLE CORRELATIONS FOR DIFFERENT GROUPS USING VARIOUS PREDICTOR COMBINATIONS

Group	Predictors	Criteria	N	R
A1	MA, SK, BLOX, PLACE, FAIL, MS, MM, ME, MAF	COMCRSAV	86	0,499
A1	MA, DRAT, SK, BLOX, PLACE, FAIL, MS, MM, ME, MAF	COMCRSAV	86	0,514
E1E	MA, BLOX, SK, TRC, PLACE, FAIL, MS, MM, ME, MAF	CAV	68	0,561
E1E	MA, DRAT, SK, TRC, PLACE, FAIL, MS, MM, ME, MAF	CAV	68	0,574
E1E	MA, DRAT, SK, BLOX, PLACE, FAIL, MS, MM, ME, MAF	CAV	68	0,560
E1E	MA, DRAT, TRC, BLOX, PLACE, FAIL, MS, MM, ME, MAF	CAV	68	0,562
E1E	MA, SK, TRC, PLACE, FAIL, MS, MM, ME, MAF	CAV	68	0,560
E1C	MA, SK, TRC, PLACE, FAIL, MS, MM, ME, MAF	CAV	53	0,709
E1M	MA, SK, TRC, PLACE, FAIL, MS, MM, ME, MAF	CAV	42	0,539
E1M	MA, BLOX, SK, PLACE, FAIL, MS, ME, MM, MAF	CAV	42	0,540
E1E	MA, BLOX, SK, PLACE, FAIL, MS, ME, MM, MAF	CAV	68	0,552
E1C	MA, BLOX, SK, PLACE, FAIL, MS, ME, MM, MAF	CAV	53	0,701
A1G	MA, GFT, BLOX, PLACE, FAIL, MS, MM, ME, MAF	COMCRSAV	50	0,761
A1G	MA, GFT, BLOX, DRAT, PLACE, FAIL, MS, MM, ME, MAF	COMCRSAV	50	0,780
A1G	MA, GFT, BLOX, DRAT, SK, PLACE, FAIL, MS, MM, ME, MAF	COMCRSAV	50	0,781

(Abbreviations in 6.2 p75)

By excluding Intake 1 from the A1 group and including the GFT as a predictor, relatively high multiple correlations can be obtained for the A1G group.

Individual common course subjects were used as criteria to ascertain whether they could be substantially predicted, but the multiple correlations obtained were all smaller than those obtained using a composite criterion.

Correlations alone, however, give no indication of the minimum predictor scores associated with success; multiple regressions are required for this purpose. In order to ascertain the most economical battery of predictors, the "Leaps and Bounds" multiple regression programme (developed by G.M. Furnival and R.W. Wilson at Yale University, 1974) was used, in which a sequence of predictors (from 1....N) yielding optimum correlations were calculated. The most suitable predictor battery was then chosen with a view to optimizing the validity of the predictor battery and facilitating administrative procedures.

6.4 Selection of a Predictor Battery for the English Group

Although the size of the English specialization groups are for statistical purposes rather small, stepwise multiple regressions were calculated for both individual and combined groups in order to see if predictive efficiencies were similar.

A. Combined English group

As can be seen in Table 6.4 the Mental Alertness has the highest single correlation with both criteria. The multiple correlations obtained using common-course-average as the criterion are in all cases higher (for the same number of predictors) than when using courses passed as the criterion, and will therefore be used as the academic criterion for this group.

It was decided that the increase of 0,05 obtained in the multiple correlation when using five predictors instead of four was marginal, thus the combination of predictors chosen to predict common-course-average are MA, BLOX, SK and FAIL,

TABLE 6.4

SUMMARY OF OPTIMUM CORRELATIONS USING COMMON-COURSE-AVERAGE AND COURSES PASSED AS CRITERIA FOR THE COMBINED ENGLISH GROUP (N=140)

NUMBER OF PREDICTORS USED	Criterion Common-Course-Average					Criterion Courses Passed			
	Best Pre-dictor (s)	R	Second Best Pre-dictor (s)	R		Best Pre-dictor (s)	R	Second Best Pre-dictor (s)	R
1.	MA	0,360	SK	0,250	1.	MA	0,320	SK	0,280
2.	MA FAIL	0,392	MA BLOX	0,374	2.	MA SK	0,353	FAIL MA	0,338
3.	MA FAIL BLOX	0,404	MA FAIL SK	0,402	3.	FAIL MA SK	0,369	ME MA SK	0,359
4.	MA BLOX SK FAIL	0,414	MA MS BLOX FAIL	0,411	4.	FAIL ME MA SK	0,377	FAIL MS MA SK	0,371
5.	MA BLOX MM SK FAIL	0,419	MA SK DRAT BLOX FAIL	0,419	5.	FAIL MS ME MA SK	0,382	FAIL ME MAF MA SK	0,381

(Abbreviations in Table 6.2 p75)

which give a multiple correlation of R = 0,414, which is significantly different from a zero correlation (at the five percent confidence level).

B. Individual English specialization groups

Multiple correlations were calculated for each English specialization group to see whether improved correlations with the criterion could be obtained, as compared to the combined English group. In predicting for individual specialization groups it is possible to utilize all criterion information, since within such groups all students do the same subjects, consequently the average for all five course subjects can be meaningfully compared.

As shown in Table 6.5 the best multiple correlation for the mechanical group is obtained predicting courses passed, using the Blox Test, Matriculation mathematics and Afrikaans as predictors (R = 0,48). Considering the small sample (N=33) it would be unwise to use more than three predictors. This correlation is significantly different from a zero correlation (at the five percent confidence level).

(See Table 6.5 p81).

The best multiple correlation obtained for the electrical group was no better than that obtained for the combined English group.

In the case of the civil group, it was found that the correlation of the SK and TRC Tests and Matriculation mathematics with the number of courses passed was R = 0,672. However, since the TRC is not included in any other predictor batteries, and since only a small decrease in the multiple correlation results from its exclusion, it was decided not to consider its inclusion in a predictor battery.

Considering the relatively small increases in the multiple correlations for the civil and mechanical specialization groups and the limited size of the groups used for analysis,

TABLE 6.5

SUMMARY OF BEST MULTIPLE CORRELATIONS USING COURSE AVERAGE AND COURSES PASSED AS CRITERIA FOR THE THREE ENGLISH SPECIALIZATION GROUPS

NUMBER OF PREDICTORS USED	Criterion - Course Average: Best Predictor (s)	R	Second Best Predictor (s)	R		Criterion - Courses Passed: Best Predictor (s)	R	Second Best Predictor (s)	R
Mechanical Group (N=33)									
1.	FAIL	0,320	MAF	0,290	1.	MAF	0,360	MM	0,210
2.	FAIL MAF	0,390	FAIL MM	0,385	2.	MAF BLOX	0,435	MM MAF	0,422
3.	FAIL MM MAF	0,447	MM MAF BLOX	0,431	3.	MM MAF BLOX	0,482	MAF BLOX DRAT	0,450
Electrical Group (N=60)									
1.	MS	0,350	SK	0,260	1.	MS	0,290	SK	0,250
2.	MS MA	0,390	MS SK	0,390	2.	MS SK	0,340	MS MA	0,338
3.	MS DRAT SK	0,415	MM MS SK	0,414	3.	MS DRAT SK	0,359	MS MA SK	0,358
Civil Group (N=47)									
1.	MA	0,550	SK	0,510	1.	SK	0,570	MA	0,570
2.	SK TRC	0,608	MS MA	0,605	2.	SK TRC	0,654	MA SK	0,631
3.	MS SK TRC	0,671	MM SK TRC	0,653	3.	MM SK TRC	0,672	MA SK TRC	0,670

(Abbreviations in Table 6.2 p75)

it was decided not to devise separate predictor batteries for these specialization groups.

In assessing the predictive role of the matriculation subjects, it should be borne in mind that there is restricted variance in the mathematics and science marks because the Witwatersrand Technikon has a minimum entrance requirement of at least a pass for these two subjects, while students doing well in these two subjects are likely to enrol at a university. This probably explains why science and mathematics did not feature as more important predictors of success.

6.5 Predictor Weights for the Combined English Group

Beta weights calculated in the regression analyses were simplified for administrative ease by rounding to one decimal point and multiplying by ten.

TABLE 6.6

SIMPLIFIED PREDICTOR WEIGHTS FOR THE COMBINED ENGLISH GROUP

Predicting the common-course-average:
5 (Mental Alertness score) + 3(Blox score) + 2 Scientific Knowledge score) - 28 (Number of school standards failed) +333

6.6 Selection of a Predictor Battery for the Afrikaans Group

The sample of Afrikaans students was far smaller (N=50) than the sample of English speaking first term engineering technicians; predictors were not calculated for individual specialization groups as the small size of the groups reduces the possibility of obtaining stable results.

The multiple regression analysis programme was run using both courses passed and common-course-average as criteria of success.

TABLE 6.7

SUMMARY OF BEST MULTIPLE CORRELATIONS USING COMMON-COURSE-AVERAGE AND COURSES PASSED AS CRITERIA FOR THE AFRIKAANS GROUP (INTAKES 2 AND 3)(N = 50)

NUMBER OF PREDICTORS USED	Criterion: Common-Course-Average				NUMBER OF PREDICTORS USED	Criterion: Courses Passed			
	Best Pre dictor (s)	R	Second Best Pre-dictor (s)	R		Best Pre-dictor (s)	R	Second Best Pre-dictor (s)	R
1.	GFT	0,520	MA	0,350	1.	GFT	0,440	TRC	0,330
2.	GFT ME	0,605	GFT MM	0,602	2.	GFT ME	0,506	GFT TRC	0,493
3.	GFT MM ME	0,664	GFT FAIL ME	0,639	3.	GFT TRC ME	0,552	GFT FAIL ME	0,548

(Abbreviations in Table 6.2, p75)

The correlation between common-course-average and courses passed was found to be R = 0,80. This correlation is of the same order as those found for the English groups, and the same strategy as used in the choice of a measure of academic success for the English group will be applied. The common-course-average will therefore be used as the criterion of success. The best combination of predictors is the Gottschaldt Figures Test and the matriculation marks obtained for English and mathematics, yielding a multiple correlation of R = 0,664 (significantly different from a zero correlation at the one percent confidence level).

Since this predictor battery includes matriculation marks which would not be obtained from future applicant technicians with N3 certificates, an alternative battery which does not use matriculation marks as predictors is necessary. The best option accommodating such a condition is the use of the Gottschaldt Figures Test alone, predicting the common-course-average (R = 0,52, significantly different from a zero correlation at the one percent confidence level).

6.7 Predictor Weights for the Afrikaans Group

Beta weights were calcualted from the regressions and simplified for admistrative ease by rounding to one decimal place and multiplying by ten.

TABLE 6.8

SIMPLIFIED PREDICTOR WEIGHTS FOR THE AFRIKAANS GROUP

A. For Matriculants Applicnats

Predicting the common-course-average:

7 (Gottschaldt Figures Test score) + 31 (Matriculation English mark) - 22 (Matriculation Mathematics mark) + 290

B. For Non-Matriculant Applicants

Predicting the common-course-average:

6 (Gottschaldt Figures Test) + 361

6.8 Discussion of Results

The initial comparison made in the analysis of results revealed that final term students differed significantly from first term students in certain respects; to summarize, they tended:

i) to come from smaller families;

ii) to fail fewer standards at school;

iii) to dislike mathematics and science, but to have obtained better results in these subjects and Afrikaans in their matriculation examinations;

iv) to have had more relevant training and also more incompleted training; and

v) to obtain higher scores on the Scientific Knowledge, Technical Reading Comprehension, Mental Alertness and Blox Tests.

It was hypothesized that differences between the two groups would indicate factors important in the prediction of success: however, not all significantly different factors were considered for inclusion as predictors of first term success as it was felt that selection of applicants should be made in terms of factors over which applicants exercised some control, such as school marks and certain test scores, rather than uncontrollable background factors like family size and place of origin. Also excluded as predictors were responses which could be faked, such as the response to the question referring to the most preferred school subjects. The finding that more final term students had not completed previous training could indicate an increased motivation after other training failures are experienced, and this could be borne in mind by Student Counsellors in selecting applicants likely to pass.

The comparison of specialization groups revealed few significant differences on compared items, thus these groups could be combined for further analyses.

Although several differences between the intake groups were found on the items compared, a number of these could be attributed to the time lapse between the samples; no variations in the selection procedures can be practically envisaged for different intake groups.

A number of important differences were found to occur between English and Afrikaans students on biographical items and the psychological tests, thus the two groups had to be separated for further analysis.

A difference was found between students from academic and technical schools in terms of the common-course-average criterion, but because of the nature of the measurements and the small number of students from technical schools, further analysis of this finding could not be made.

The intercorrelations revealed that the Gottschaldt Figures Test correlated highest with the criterion of success for the Afrikaans group, whilst it correlated the lowest of all the psychological tests for the English group.

It was expected from other similar studies that scholastic achievement in mathematics and science would correlate at a higher level with the criteria of success than actually occurred; this is ascribed to the limited variance in the relevant matriculation marks in these subjects. However, matriculation mathematics acting as supressor variable, was included in the prediction formula for Afrikaans matriculants.

The scatter-plots of the two language groups (Fig. 6.1, p 92, Figs 6.2 and 6.3, p 93, 94) indicate a satisfactory occurrance of actual success amongst higher prediction scores in the case of both English and Afrikaans groups. However, the prediction of failure amongst lower predictor scores in the case of the English group is far less efficient than in the case of the Afrikaans group. This is attributed largely to a more casual attitude towards testing by the English students; by increasing their motivation to do their best on the tests, it is thought that better predictive efficiency could be achieved.

Fairly poor prediction of success also occurs amongst the middle range predictor scores, especially in the case of the Afrikaans group, indicating that a flexible procedure should be followed in selecting applicants with such scores. Such an approach is outlined in paragraphs 6.9.2 and 6.9.3, although other approaches can be devised by the Student Counsellors. The point to be noted is that in such areas of poor predictive efficiency, all relevant information on the applicant should be carefully considered before a final decision is made.

6.9 Practical Implementation of Findings

6.9.1 Introduction

A difficulty arising from having different predictors and weights for a number of sub-groups applying to the same faculties is how to select the best applicants from the total group. What follows is a description of one of a number of possible means of selecting the best students, making use of the findings of the study.

The approach taken will be as follows:

a) to devise an equitable selection ratio for the English/Afrikaans sub-groups;

b) on the basis of the selection ratio and the efficiency of the predictors, (as reflected in the scatter plot diagrams) to position upper and lower cut-off points such that the large majority of those accepted do pass the course and most of those who are rejected actually fail the course.

The nature of the predictions obtained resulted in greater efficiency in achieving the objectives of (b) in the case of the Afrikaans group; however it is thought that greater efficiency in prediction may be obtained if future applicants know that their acceptance into the Technikon is greatly dependent on the scores they obtain on the tests. This motivation to try hard on the tests was absent in the experimental sample, and it is thought that the English group made less effort on the tests than the Afrikaans group.

Although the predictors used did not yield particularly efficient predictions of failure in the case of the combined English group, an increase in the number of applicants with similar academic potential would result in lower failure rates. For example, a selection ratio of two out of three (in terms of the prediction scores) for the combined English group would decrease the failure rate by 6%, thus the efficiency of the predictors is affected to some extent by the selection ratio.

6.9.2 Selection ratio for the English and Afrikaans applicants

Two variables should be taken into account in deciding how many English and Afrikaans applciants should be allocated places in the relevant engineering faculties:

a) the pass/fail ratio of each group
b) the number of students enrolled for the courses from each group.

In terms of the common-course-average criterion of success, 69,3 percent of the English students passed, compared to 46 percent of the Afrikaans students. The total number of English and Afrikaans students was 201 and 98 respectively. It is assumed that the pass rates would not be different for the total number of students (since only 140 English and 50 Afrikaans students were analysed), and the proposed <u>language selection ratio</u> is arrived at as follows:

English $\frac{69,3}{100} \times \frac{201}{1} = 139,29$

Afrikaans $\frac{46}{100} \times \frac{98}{1} = 45,08$

<u>Afrikaans/English Selection Ratio</u> = <u>1 : 3,09</u>

TABLE 6.9

ACTUAL FAIL AND PASS RATES OF ACCEPTED AND REJECTED STUDENTS IN TERMS OF SUGGESTED CUT-OFF POINTS

Group	Number and Percentage of Group Accepted for Course		Failures* in Accepted Group		Number and Percentage of Group Rejected for Course		Passes in Rejected Group	
	N	Percentage	N	Percentage	N	Percentage	N	Percentage
Combined English	72	51,4	16	22,2	14	10	5	35,7
Afrikaans (Including Matric marks as Predictors)	13	26	2	15,4	10	20	0	0
Afrikaans (Without Matric marks as Predictors)	13	26	2	15,4	7	14	0	0

* Failure defined as: (i) Passing less than 3 courses, or
(ii) Obtaining less than 50% for common-course-average.

This ratio is a reflection of the number of students from from each language group who pass the course, and should not be regarded as fixed - should changes occur in the annual average success rate or number of applicants, the ratio must also change. Thus the language selection ratio should be checked annually.

6.9.3 Cut-Off Points

Since it is never possible to predict accurately whether each applicant will pass or fail, it has been decided to indicate two cut-off points for each group : an upper one, above which it is predicted that most of the applicants will pass the subjects, and a lower one, below which the majority of applicants will predictably fail, Between these two cut-off points, the highest scoring applicants can, as a general rule, be regarded as the most suitable. However, the intention in having two cut-off points is to allow for flexibility in the assessment of such students, especially in view of the relatively greater occurrence of inconsistencies (i.e. Type 1 and Type 2 errors) amongst middle level prediction scores.

Bearing in mind that the language selection ratio is approximately three English applicants to one Afrikaans applicant, the cut-off points for the two language groups have been positioned so that approximately 50 percent of the English applicants and 26 percent of the Afrikaans applicants (or a ratio of approximately 2 : 1) are accepted for the course in terms of their predictor scores alone. This acceptance ratio in terms of the predictor scores alone must reflect the direction of the language selection ratio, but its specific determination should be made empirically after examination of plots of the actual distribution of scores; by using scatter plots of predicted scores against actual scores (eg. Figure 6.1, p 92) it is possible to position the upper cut-off points so as to maximize actual passes amongst the predicted passes, and similarly with the lower cut-off points.

If changes in the language selection ratio occur, adjustments in the acceptance ratio can me made, within the constraint that, of those who are accepted for the course in terms of their predictor scores, at least 70 percent of them actually pass the course; ideally, no-one predicted to fail should pass, but it can be seen that the predictive efficiency of this aspect for the English group is not particularly high. However, Nunnally (1967) has suggested that even validities of between 0,30 to 0,40 can markedly improve performance in various settings.

A. English Group : Cut-Off Points

In order to know which predictor weights to use, applicants must be classified according to the flow diagram in Chapter 7 (Figure 7.1, p 99).

The number of vacancies open to English applicants depends on the language selection ratio. Applicants who obtain predictor scores equal to or above the upper cut-off points (indicated on the scatter plot, see Fig 6.1) can all be accepted for the course. Thereafter, the task of the Student Counsellor will be to select the best applicants falling between the upper and lower cut-off points and redirecting unsuitable applicants to more appropriate vocations where necessary, basing decisions on all available information, and in borderline cases after conducting in-depth interviews.

B. Afrikaans Group : Cut-Off Points

No separate specialization groups have been examined in the case of the Afrikaans students because the sample size was too small. Scatter plots and cut-off points have been calculated separately for application to future Afrikaans applicants with and without matriculation exemption; in both cases, applicants with predictor scores equal to or above the upper cut-off points can be accepted for the course, and if more students are still needed to fill the number of vacancies apportioned to Afrikaans students (in terms of the

FIGURE 6.1

SCATTER PLOT AND CUT-OFF POINTS OF THE COMBINED ENGLISH GROUP. (N =140)

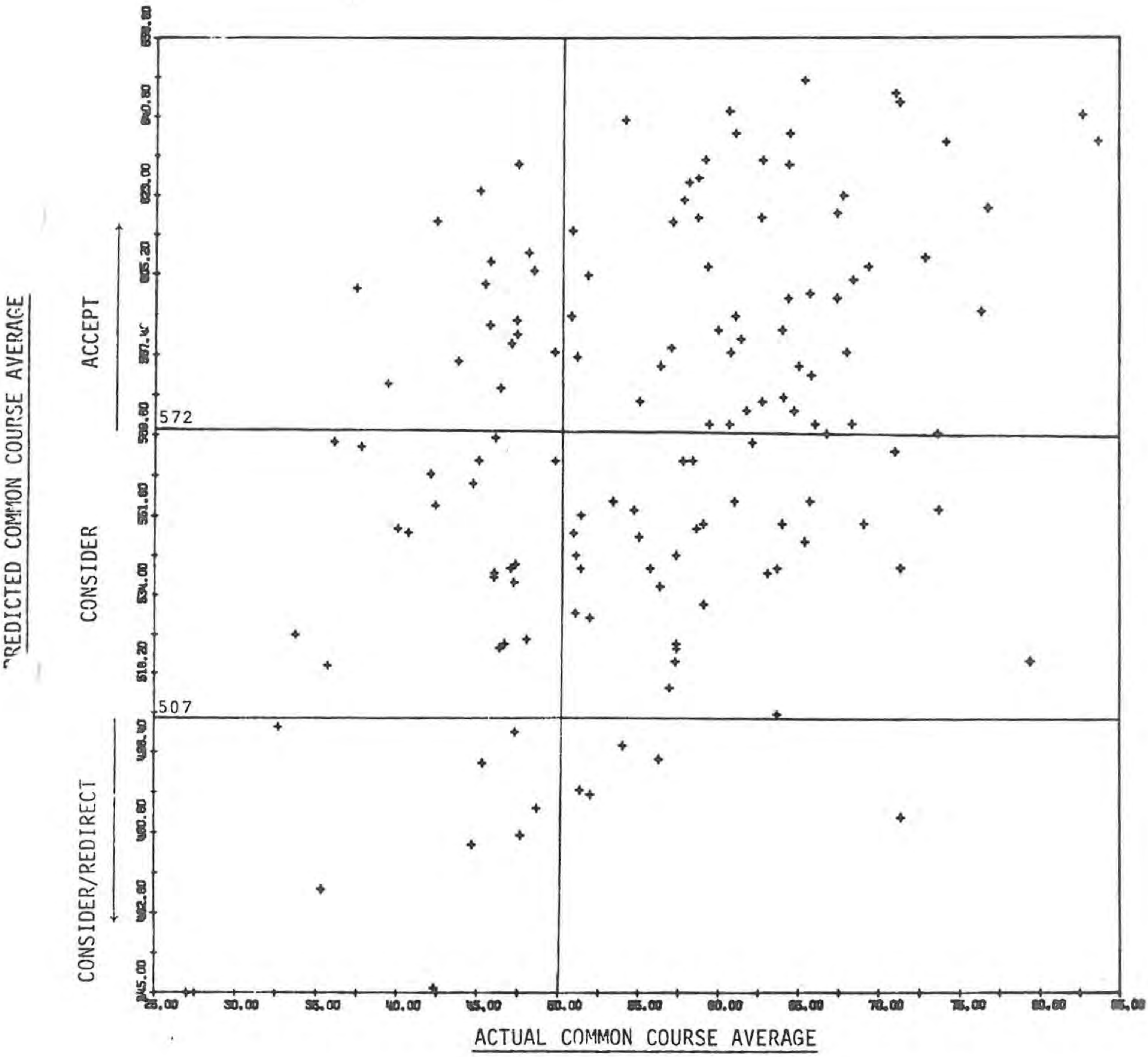


FIGURE 6.2

SCATTER PLOTS AND CUT-OFF POINTS OF THE AFRIKAANS GROUP (INCLUDING MATRICULATION MARKS AS PREDICTORS). (N = 50)

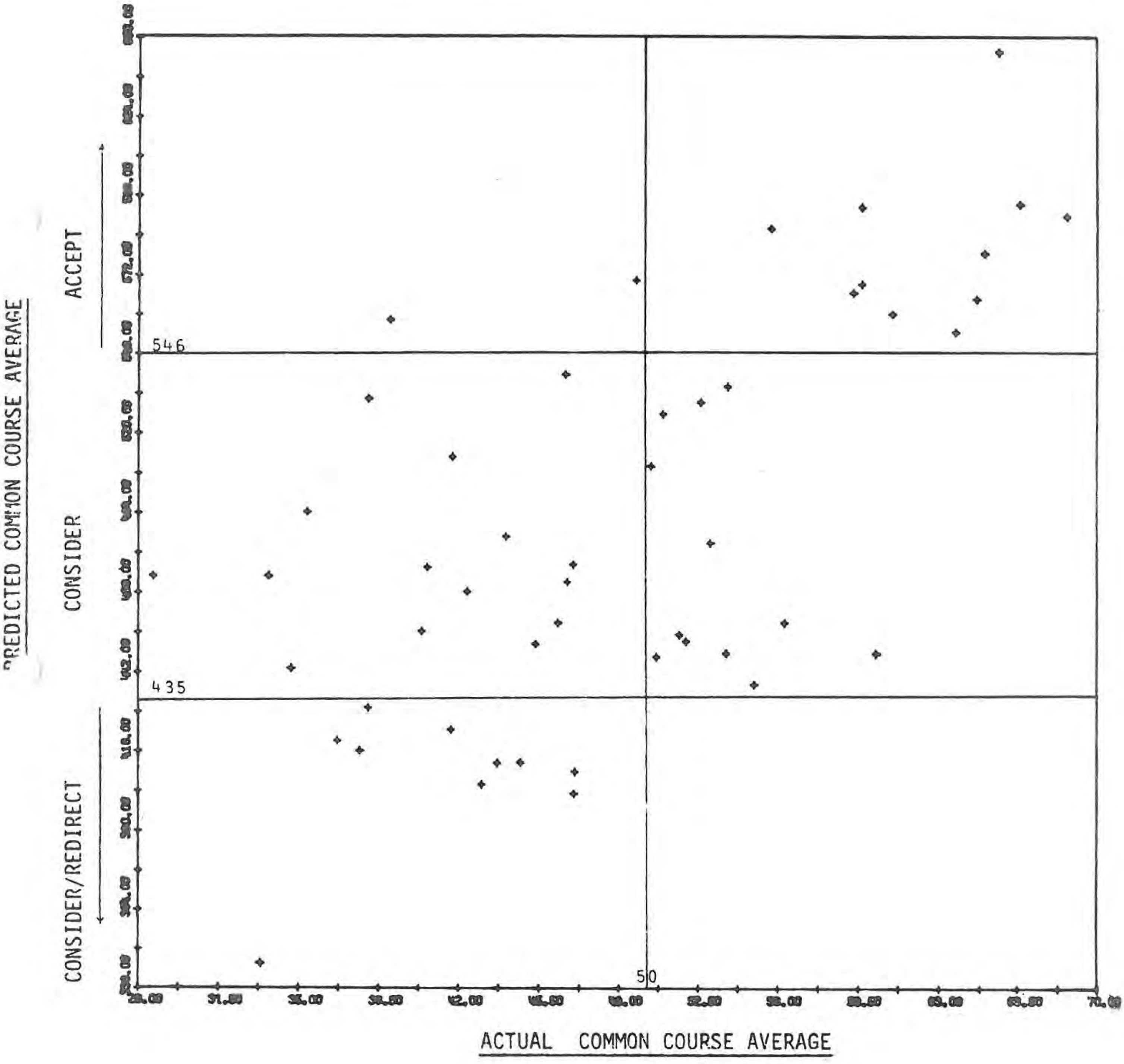
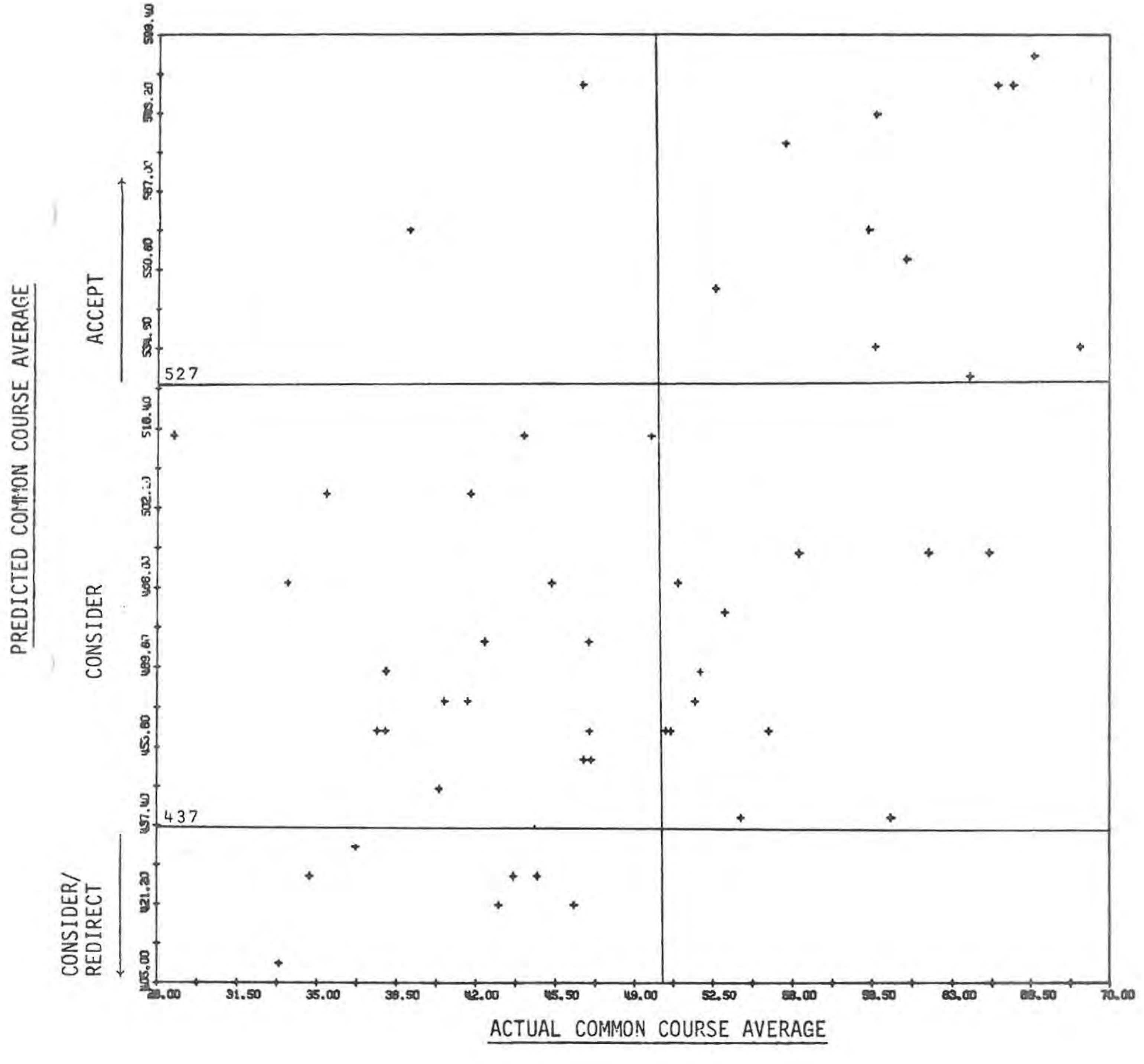


FIGURE 6.3

SCATTER PLOT AND CUT-OFF POINTS OF THE AFRIKAANS GROUP (USING NO MATRICULATION MARKS AS PREDICTORS). (N = 50)



language selection ratio - see 6.9.2), selection of matriculant and non-matriculant applicants between the two cut-off points should be done on an individual case-study approach by the Student Counsellor. Unsuitable applicants can be redirected to more appropriate vocations.

6.9.4 Norms

Norms have been calculated for each predictor battery (see Appendix, A.21 to A.23), and for the individual tests (Appendix, A.1 to A.12) for each group analysed. Distributions of all scores have been placed on normal distribution curves, allowing each raw score to be compared to its norm group. An indication of each score's relative standing in the normative sample can thus be gained, which permits an evaluation of individual test performances. The standardized scores have been divided into stanines - nine classes of scores made up of the following percentages:

Percentage of Group	4%	7%	12%	17%	20%	17%	12%	7%	4%
Stanine	1	2	3	4	5	6	7	3	9

6.9.5 Summary of cut-off points

TABLE 6.10

SUMMARY OF CUT-OFF POINTS FOR ALL GROUPS

Group	Cut-Off Points		
	Accept	Consider	Consider / Redirect
Combined English	≥572	508 - 571	≤507
Afrikaans (matriculants)	≥546	436 - 545	≤435
Afrikaans (non-matriculants)	≥527	438 - 526	≤437

It is suggested that the Student Counsellors at the Witwatersrand Technikon use the cut-off points flexibly as aids in selecting successful engineering technicians, and in redirecting to more suitable vocations those likely to fail the course. However, not all the practical implementation problems can be foreseen at this stage, and it should become apparent to those intimately involved in such work that other methods, such as making case studies of all applicants with stanines of less than, say, three, on the norms for combined predictor scores, could be followed. One practical problem which could not be taken into account in the present study (because of the relatively small numbers of students involved), is the non-English or -Afrikaans applicants to Technikons. A pragmatic solution as to how many foreign students to accept for the relevant engineering Diploma courses will need to be made; for example, previous success rates of such students could be obtained from records and a proportionate number of those students with the best predictor scores in terms of the predictor battery used for the combined English group could be accepted. It seems impractical to consider validating predictor batteries for every minority ethnic group in South Africa.

CHAPTER SEVEN

7. RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

7.1 Framework for Applying Results

The selection strategy described in this study is envisaged as a function of the proposed student counselling service for Technikons. However, the specific selection formulae obtained were based on the analysis of specific Diploma groups at a particular Technikon. It cannot be assumed that these selection formulae will be applicable to different student populations or other engineering courses without conducting new validation studies. In the absence of such information, the tests found here to be valid, in conjunction with other appropriate tests (see 7.2.v) could be used in a counselling approach as a base for recommendations to applicants wishing to pursue engineering courses.

It is suggested that selection decisions made by Student Counsellors at the Witwatersrand Technikon should not necessarily be based on predictor test scores alone, but should also take into consideration information gained from other tests administered and in some cases from an in-depth interview. In this manner it should be possible to identify and redirect student applicants who are following wrong vocational paths. A suitably chosen battery of tests for general vocational guidance, and not the cheapest selection battery for a mechanistic screening, should thus be administered to all applicants.

7.2 Proposals Based on Findings of the Study

i) It is suggested that existing minimum entrance requirements at the Witwatersrand Technikon Engineering faculties be retained; the predictive validity of mathematics and science was not adequately ascertained in the present study due to the limited range of scores in these subjects, but many previous studies have found a significant relationship between such school subjects and engineering courses.

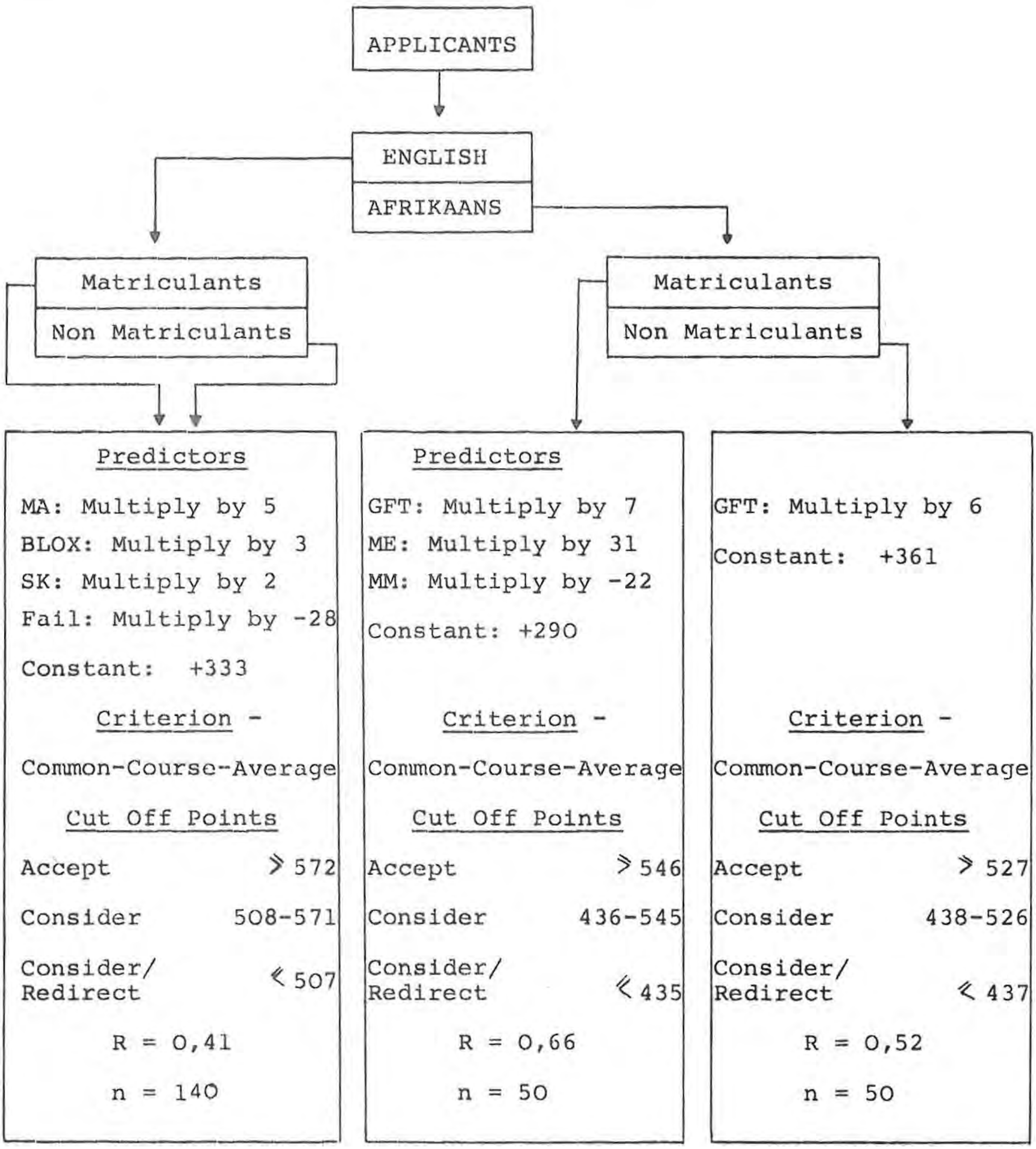
ii) The following flow diagram is suggested as a guide for implementing the proposed selection procedure at the Witwatersrand Technikon, (see Figure 7,1 p99)

iii) It is suggested that all applicants to the civil, electrical and mechanical engineering courses at the Witwatersrand Technikon who obtain predictor scores below the upper cut-off points (see Figs. 6.1 to 6.3) be considered for acceptance by the Student Counsellor; predictor scores can be used as an initial indication of likely success, but all relevant factors including abilities, interest fields, general background, over-or under-achievement at school and general academic orientation should be assessed. In cases of borderline acceptability, applicants should be interviewed so that factors such as motivation, attitude towards testing, emotional factors and personality stability can be assesed. Unsuitable applicants can be redirected into more suitable careers. Applicants scoring below the lower cut-off point have a good chance of failing and a careful assessment for other compensating factors should be made. Applicants obtaining predictor scores above the upper cut-off point can be accepted for the course in a ratio which reflects the number of students passing the courses from each language group (see 6.9.2). These ratios should be checked annually and adjusted if changes in them occur.

iv) It is suggested that all applicants to the mechanical, electrical and civil engineering faculties be tested together, before the start of each trimester, and that they fill out an abbreviated biographical questionnaire (see original questionnaire, Appendix, A.35) and an interest blank.

FIGURE 7.1

FLOW DIAGRAM OF PROPOSED SELECTION PROCESS



(See Table 6.2, p 75 for abbreviations of predictors)

v) Apart from the minimum test battery of the Mental Alertness, Scientific Knowledge and Blox Tests (for English speaking applicants) and the Gottschaldt Figures Test (for Afrikaans speaking applicants), other NIPR Tests which could assist the Student Counsellors in giving vocational advice to applicants wishing to be trained in the engineering and physical science fields are the Arithmetical Problems (A/68) and the Pattern Relations (A/15/1) Tests for both language groups. In addition the Afrikaans groups could also complete the Mental Alertness, Scientific Knowledge and Blox Tests. (See Visser (1977) for further information on NIPR tests for counselling purposes).

vi) Since the selection batteries were validated on English and Afrikaans home language samples only, selection of other language groups could pose problems. One solution has been suggested in 6.9.5 (p95), or else the student counsellor could use his discretion in selecting such applicants in terms of their scores on non-verbal tests. However, since the course must be taught through the medium of an official language, an English or Afrikaans comprehension test could also prove a useful prediction instrument.

vii) Test administrators must be suitably qualified and trained, and strict testing standards must be maintained. It is recommended that a confidential file for the protocols of each applicant be kept, together with all his academic results, so that future research into this area can draw upon a large amount of data. It might be possible to facilitate storage and future research by computerizing all such information.

7.3 Suggestions for Further Research

a) Although the present study was limited by the small sample sizes, the data has by no means been exhaustively analysed, and could lend itself to further research findings.

b) The predictors were not comprehensive and could possibly be improved by a new test of mathematical ability, especially in the case of the electrical and combined English groups.

c) The linear additive model used in this prediction exercise may not have been the best model to use, and other models could be experimented with.

d) An interesting area for further inquiry is the problem of applicants who obtain a high predictor score but fail to pass their course subjects. This represents an obvious waste of potential and it is thought that a study in this area may reveal certain personality or temperamental patterns.

e) It is suggested that another validation study be carried out where substantial sample sizes are available for the validation of individual specialization groups of both English and Afrikaans speaking applicants. With a larger sample, more predictors can be safely used.

f) It may be of interest to analyse a group of drop-out students separately from the other students to see whether any patterns emerge. A possible difference between drop-out and failure students could be that the latter lack the ability whilst the former made poor career decisions.

g) It is suspected that some of the students tested for the present study were often unmotivated to do their best on the tests administered because of the perceived lack of relevance of the testing exercise and the extremely long battery of tests endured. However, with a shorter battery of tests upon which acceptance into a faculty will to some extent depend, a different attitude should prevail.

h) The reported difference found between students from technical and academic schools in common-course-average should be followed up to see whether it is consistent; should this be the case, Technikons may need to channel all applicants from technical schools through their "pre-technician" course.

i) It is suggested that the findings of this study be applied to other Technikons and either revalidated or checked to see whether improvements in the pass rates occur.

7.4 Conclusion

Although the object of this study is to reduce the number of failures and drop-outs among first term engineering students, it has also been pointed out that a shortage of technicians exists in South Africa. Thus student counsellors must be circumspect in rejecting applicants. However, by publicising that entrance into the engineering fields is not automatic but dependent on ability, a more positive and attractive image could be created which may increase the number and calibre of applicants to the faculties concerned. All ethnic groups in South Africa should be encouraged and recruited for training to overcome the shortage of engineering technicians.

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NORMS

Test: Mental Alertness (High Level)

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg.
1st Term Mechanical, Electrical and Civil Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: English

Age Range: 19,93 - 20,40 years (within 95% confidence limits)

Mean: 20,16 years

Standard Deviation: 1,92

Education Range: All Matriculated

Sex: Predominantly males

Test Statistics:

Mean: 25,44

Standard Deviation: 5,57

Sample Size: 163

Reliability Coefficients:

1) Kuder-Richardson 21: 0,693
2) Kuder-Richardson 21 (with Tucker Correction for Uniform (C,1) distribution): 0,808

APPENDIX A. 1.

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
25	11	-2.63	24	1	1
28	12	-2.38	26	1	1
28	13	-2.21	28	1	1
30	14	-2.09	29	1	1
31	15	-1.95	31	1	2
34	16	-1.72	33	2	2
37	17	-1.45	36	2	3
38	18	-1.25	37	2	3
40	19	-1.10	39	3	3
41	20	-0.96	40	3	3
42	21	-0.84	42	3	4
43	22	-0.73	43	4	4
45	23	-0.56	44	4	4
47	24	-0.39	46	4	5
49	25	-0.23	48	5	5
50	26	-0.05	49	5	5
52	27	0.11	51	5	6
54	28	0.27	53	6	6
55	29	0.45	54	6	6
57	30	0.64	56	6	7
60	31	0.86	59	7	7
62	32	1.07	61	7	8
64	33	1.28	63	8	8
67	34	1.56	66	8	9
71	35	1.90	69	9	9
75	36	2.30	73	9	10
75	37	2.50	75	9	10
75	38	2.50	75	9	10
77	39	2.62	76	9	10

N O R M S

Test: Verstandelike Helderheid (Höe Vlak)

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: Afrikaans

Age Range: 19,98 - 20,79 years (within 95% confidence limits)

Mean: 20,38 years

Standard Deviation: 1,94

Education Range: All Matriculated

Sex: Male

Test Stastics:

Mean: 25,38

Standard Deviation: 5,49

Sample Size: 86

Reliability Coefficients:

1) Kuder-Richardson 21 : 0,683

2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution) : 0,801

APPENDIX A. 2

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
25	11	-2.65	23	1	1
27	12	-2.40	26	1	1
27	13	-2.27	27	1	1
29	14	-2.19	28	1	1
32	15	-1.96	30	1	1
34	16	-1.69	33	2	2
36	17	-1.46	35	2	2
38	18	-1.26	37	2	3
40	19	-1.10	39	3	3
41	20	-0.98	40	3	3
42	21	-0.87	41	3	4
43	22	-0.75	42	3	4
44	23	-0.63	44	4	4
46	24	-0.48	45	4	4
49	25	-0.27	47	4	5
51	26	-0.00	50	5	5
54	27	0.25	53	6	6
55	28	0.41	54	6	6
56	29	0.52	55	6	6
57	30	0.65	56	6	7
60	31	0.87	59	7	7
63	32	1.15	61	7	8
65	33	1.41	64	8	8
67	34	1.60	66	8	9
68	35	1.75	67	8	9
70	36	1.90	69	9	9
71	37	2.05	71	9	10
75	38	2.32	73	9	10

NORMS

Test: Blox

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: English

Age Range: 19,93 - 20,40 years (within 95% confidence limits)

Mean: 20,16 years

Standard Deviation: 1,92

Education Range: All Matriculated

Sex: Predominantly males

Test Statistics:

Mean: 34,52

Standard Deviation: 4,24

Sample Size: 163

Reliability Coefficients:

1) Kuder-Richardson 21: 0,564
2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution) : 0,777

APPENDIX A.3

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
23	22	-2.86	21	1	1
25	23	-2.62	24	1	1
25	24	-2.50	25	1	1
28	25	-2.38	26	1	1
30	26	-2.11	29	1	1
33	27	-1.81	32	1	2
36	28	-1.52	35	2	2
38	29	-1.31	37	2	3
40	30	-1.14	39	3	3
42	31	-0.93	41	3	4
44	32	-0.71	43	4	4
46	33	-0.49	45	4	4
49	34	-0.25	48	5	5
51	35	-0.01	50	5	5
53	36	0.17	52	5	6
55	37	0.36	54	6	6
57	38	0.60	56	6	7
60	39	0.89	59	7	7
63	40	1.18	62	7	8
66	41	1.48	65	8	8
70	42	1.80	68	9	9
74	43	2.16	72	9	10
77	44	2.55	75	9	10

NORMS

Test: Blox

Description of Samples:

Sample: Witwatersrand Technikon, Johannesburg
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: Afrikaans

Age Range: 19,98 - 20,79 years (within 95% confidence limits)

Mean: 20,38 years

Standard Deviation: 1,94

Education Range: All Matriculated

Sex: Male

Test Statistics:

Mean: 33,09

Standard Deviation: 4,57

Sample Size: 86

Reliability Coefficients:

1) Kuder-Richardson 21: 0,594
2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0, 777

APPENDIX A.4

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
25	21	-2.73	23	1	1
29	22	-2.32	27	1	1
31	23	-2.00	30	1	1
33	24	-1.82	32	1	2
33	25	-1.71	33	2	2
35	26	-1.58	34	2	2
37	27	-1.37	36	2	3
39	28	-1.17	38	3	3
41	29	-0.98	40	3	3
43	30	-0.76	42	3	4
45	31	-0.57	44	4	4
47	32	-0.41	46	4	5
49	33	-0.23	48	5	5
51	34	-0.02	50	5	5
53	35	0.21	52	5	6
56	36	0.45	55	6	6
58	37	0.71	57	6	7
62	38	1.01	60	7	7
64	39	1.28	63	8	8
67	40	1.54	65	8	8
68	41	1.75	67	8	9
70	42	1.90	69	9	9
75	43	2.26	73	9	10

N O R M S

Test: DRAT (Intermediate)

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: English

Age Range: 19,93 - 20,40 years (within 95% confidence limits)

Mean: 20,16 years

Standard Deviation: 1,92

Education Range: All Matriculated

Sex: Predominantly males

Test Statistics:

Mean: 17,14

Standard Deviation: 5,19

Sample Size: 162

Reliability Coefficients:

1) Kuder-Richardson 21: 0,753
2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0,848

APPENDIX A. 5

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
23	3	-2.86	21	1	1
25	4	-2.62	24	1	1
25	5	-2.50	25	1	1
26	6	-2.43	26	1	1
31	7	-2.14	29	1	1
35	8	-1.73	33	2	2
37	9	-1.42	36	2	3
38	10	-1.23	38	3	3
40	11	-1.09	39	3	3
41	12	-0.98	40	3	3
42	13	-0.86	41	3	4
43	14	-0.73	43	4	4
44	15	-0.61	44	4	4
46	16	-0.46	45	4	4
49	17	-0.23	48	5	5
51	18	0.02	50	5	5
53	19	0.23	52	5	6
55	20	0.40	54	6	6
57	21	0.59	56	6	7
60	22	0.83	58	7	7
61	23	1.04	60	7	7
63	24	1.23	62	7	8
66	25	1.46	65	8	8
68	26	1.69	67	8	9
71	27	1.94	69	9	9
77	28	2.41	74	9	10

N O R M S

Test: DRAT (Intermediѐre)

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3different groups)

Racial Group: Europeans

Testing Language: Afrikaans

Age Range: 19,98 - 20,79 years (within 95% confidence limits)

Mean: 20,38 years

Standard Deviation: 1,94

Education Range: All Matriculated

Sex: Male

Test Statistics:

Mean: 13,59

Standard Deviation: 5,10

Sample Size: 85

Reliability Coefficients:

1) Kuder-Richardson 21: 0,738
2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0,837

APPENDIX A.6

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
25	0	-2.65	24	1	1
27	1	-2.39	26	1	1
27	2	-2.27	27	1	1
27	3	-2.27	27	1	1
27	4	-2.27	27	1	1
31	5	-1.08	29	1	1
34	6	-1.75	32	1	2
36	7	-1.50	35	2	2
39	8	-1.23	38	3	3
42	9	-0.93	41	3	4
44	10	-0.70	43	4	4
45	11	-0.56	44	4	4
47	12	-0.42	46	4	5
49	13	-0.22	48	5	5
51	14	-0.00	50	5	5
53	15	0.20	52	5	6
55	16	0.41	54	6	6
57	17	0.63	56	6	7
60	18	0.85	58	7	7
61	19	1.01	60	7	7
62	20	1.13	61	7	8
64	21	1.27	63	8	8
65	22	1.41	64	8	8
66	23	1.54	65	8	8
68	24	1.71	67	8	9
71	25	1.96	70	9	9
75	26	2.31	73	9	10

N O R M S

Test: Technical and Scientific Knowledge Test

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: English

Age Range: 19,93 - 20,40 years (within 95% confidence limits)

Mean: 20,16 years

Standard Deviation: 1,92

Education Range: All Matriculated

Sex: Predominantly males

Test Statistics:

Mean: 21,54

Standard Deviation: 4,84

Sample Size: 163

Reliability Coefficients:

1) Kuder-Richardson 21 : 0,666
2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0,793

APPENDIX A. 7

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
25	8	-2.68	23	1	1
28	9	-2.33	27	1	1
29	10	-2.13	29	1	1
30	11	-2.06	29	1	1
32	12	-1.89	31	1	2
35	13	-1.65	34	2	2
36	14	-1.50	35	2	2
37	15	-1.39	36	2	3
39	16	-1.24	38	3	3
41	17	-1.04	40	3	3
42	18	-0.86	41	3	4
44	19	-0.69	43	4	4
47	20	-0.47	45	4	4
49	21	-0.24	48	5	5
50	22	-0.04	50	5	5
52	23	0.14	51	5	6
54	24	0.33	53	6	6
57	25	0.54	55	6	6
59	26	0.77	58	7	7
61	27	1.01	60	7	7
63	28	1.23	62	7	8
66	29	1.46	65	8	8
70	30	1.81	68	9	9
75	31	2.26	73	9	10

N O R M S

Test: Tegniese en Wetenskaplike Kennistoets

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: Afrikaans

Age Range: 19,98 - 20,79 years (within 95% confidence limits)

Mean: 20,38 years

Standard Deviation: 1,94

Education Range: All Matriculated

Sex: Male

Test Statistics:

Mean: 16,95

Standard Deviation: 5,06

Sample Size: 84

Reliability Coefficients:

1) Kuder-Richardson 21: 0,677
2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0,794

APPENDIX A.8

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
25	4	-2.64	24	1	1
27	5	-2.39	26	1	1
27	6	-2.26	27	1	1
27	7	-2.26	27	1	1
27	8	-2.26	27	1	1
27	9	-2.26	27	1	1
32	10	-2.03	30	1	1
36	11	-1.59	34	2	2
40	12	-1.21	38	3	3
42	13	-0.92	41	3	4
45	14	-0.64	44	4	4
49	15	-0.30	47	4	5
51	16	-0.02	50	5	5
52	17	0.12	51	5	6
53	18	0.23	52	5	6
55	19	0.40	54	6	6
57	20	0.59	56	6	7
58	21	0.71	57	6	7
58	22	0.79	58	7	7
60	23	0.91	59	7	7
62	24	1.07	61	7	8
63	25	1.25	62	7	8
66	26	1.45	65	8	8
68	27	1.68	67	8	9
71	28	1.95	70	9	9
75	29	2.31	73	9	10

N O R M S

Test: Technical Reading Comprehension

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: English

Age Range: 19,93 - 20,40 years (within 95% confidence limits)

Mean: 20,16 years

Standard Deviation: 1,92

Education Range: All Matriculated

Sex: Predominantly males

Test Statistics:

Mean: 19,84

Standard Deviation: 5,15

Sample Size: 163

Reliability Coefficients:

1) Kuder-Richardson 21: 0,772
2) Kuder-Richardson 21 (with Tucher Correction for uniform (C,1) distribution); 0,869

APPENDIX A. 9

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
23	6	-2.87	21	1	1
26	7	-2.55	25	1	1
28	8	-2.26	27	1	1
30	9	-2.07	29	1	1
33	10	-1.84	32	1	2
35	11	-1.63	34	2	2
36	12	-1.49	35	2	2
37	13	-1.38	36	2	3
39	14	-1.24	38	3	3
41	15	-1.02	40	3	3
43	16	-0.81	42	3	4
44	17	-0.65	43	4	4
46	18	-0.49	45	4	4
48	19	-0.29	47	4	5
50	20	-0.09	49	5	5
52	21	0.08	51	5	6
54	22	0.27	53	6	6
56	23	0.47	55	6	6
58	24	0.67	57	6	7
59	25	0.86	59	7	7
61	26	1.05	60	7	7
64	27	1.27	63	8	8
66	28	1.49	65	8	8
69	29	1.76	68	9	9
75	30	2.21	72	9	10

N O R M S

Test: Tegniese Leesbegrip

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: Afrikaans

Age Range: 19,98 - 20,79 years (within 95% confidence limits)

Mean: 20,38 years

Standard Deviation: 1,94

Education Range: All Matriculated

Sex: Male

Test Statistics:

Mean: 21,62

Standard Deviation: 8,44

Sample Size: 50

Reliability Coefficients:

1) Kuder-Richardson 21: 0,861
2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0,915

APPENDIX A. 10

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
25	4	-2.64	24	1	1
27	5	-2.39	26	1	1
27	6	-2.26	27	1	1
27	7	-2.26	27	1	1
27	8	-2.26	27	1	1
29	9	-2.18	28	1	1
33	10	-1.88	31	1	2
36	11	-1.53	35	2	2
38	12	-1.28	37	2	3
40	13	-1.10	39	3	3
41	14	-0.94	41	3	4
44	15	-0.75	43	4	4
46	16	-0.53	45	4	4
48	17	-0.29	47	4	5
51	18	-0.05	50	5	5
53	19	0.17	52	5	6
55	20	0.39	54	6	6
58	21	0.63	56	6	7
59	22	0.84	58	7	7
62	23	1.04	60	7	7
65	24	1.31	63	8	8
69	25	1.68	67	8	9
73	26	2.07	71	9	10
73	27	2.26	73	9	10
75	28	2.39	74	9	10

NORMS

Test: Gottschaldt Figures Test

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: English

Age Range: 19,93 - 20,40 years (within 95% confidence limits)

Mean: 20,16 years

Standard Deviation: 1,92

Education Range: All Matriculated

Sex: Predominantly male

Test Statistics:

Mean: 20,83

Standard Deviation: 9,01

Sample Size: 109

Reliability Coefficients:

1) Kuder-Richardson 21: 0,882

2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0,929

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
24	3	-2.73	23	1	1
26	4	-2.48	25	1	1
26	5	-2.36	26	1	1
29	6	-2.22	28	1	1
33	7	-1.89	31	1	2
35	8	-1.59	34	2	2
36	9	-1.45	35	2	2
37	10	-1.35	37	2	3
39	11	-1.21	38	3	3
40	12	-1.05	39	3	3
42	13	-0.88	41	3	4
44	14	-0.70	43	4	4
45	15	-0.55	44	4	4
46	16	-0.43	46	4	5
48	17	-0.30	47	4	5
48	18	-0.20	48	5	5
50	19	-0.10	49	5	5
51	20	0.01	50	5	5
51	21	0.09	51	5	6
52	22	0.14	51	5	6
53	23	0.22	52	5	6
54	24	0.31	53	6	6

cont........

APPENDIX A. 11

APPENDIX A. 11

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
55	25	0.40	54	6	6
55	26	0.50	55	6	6
56	27	0.58	56	6	7
57	28	0.64	56	6	7
57	29	0.70	57	6	7
58	30	0.79	58	7	7
60	31	0.90	59	7	7
61	32	1.03	60	7	7
63	33	1.19	62	7	8
65	34	1.36	64	8	8
66	35	1.50	65	8	8
66	36	1.60	66	8	9
67	37	1.69	67	8	9
68	38	1.76	68	9	9
69	39	1.82	68	9	9
70	40	1.92	69	9	9
71	41	2.04	70	9	9
74	42	2.22	72	9	10

NORMS

Test: Gottschaldt Toets

Description of Sample:

Sample: Witwatersrand Technikon, Johannesburg:
1st Term Mechanical, Electrical and Civil
Engineering Technicians.

Date of Testing: September 1975 - June 1976 (3 different groups)

Racial Group: Europeans

Testing Language: Afrikaans

Age Range: 19,98 - 20,79 years (within 95% confidence limits)

Mean: 20,38 years

Standard Deviation: 1,94

Education Range: All Matriculated

Sex: Male

Test Stastics:

Mean: 21,62

Standard Deviation: 8,44

Sample Size: 50

Reliability Coefficients:

1) Kuder-Richardson 21: 0,861

2) Kuder-Richardson 21 (with Tucker Correction for uniform (C,1) distribution): 0,915

APPENDIX A. 12

Unsmoothed Standard Score	Raw Score	Unit Normal Score	Standard Score	Stanine	Sten
27	8	-2.48	25	1	1
29	9	-2.21	28	1	1
32	10	-1.92	31	1	2
36	11	-1.57	34	2	2
38	12	-1.26	37	2	3
40	13	-1.09	39	3	3
41	14	-0.96	40	3	3
42	15	-0.85	41	3	4
44	16	-0.68	43	4	4
47	17	-0.44	46	4	5
48	18	-0.26	47	4	5
49	19	-0.14	49	5	5
50	20	-0.06	49	5	5
51	21	0.04	50	5	5
53	22	0.18	52	5	6
54	23	0.32	53	6	6
54	24	0.41	54	6	6
55	25	0.47	55	6	6
56	26	0.54	55	6	6
57	27	0.63	56	6	7
57	28	0.69	57	6	7
58	29	0.75	58	7	7
59	30	0.84	58	7	7
59	31	0.89	59	7	7
60	32	0.94	59	7	7
61	33	1.04	60	7	7
62	34	1.15	62	7	8
62	35	1.20	62	7	8
62	36	1.22	62	7	8
64	37	1.31	63	8	8
67	38	1.51	65	8	8
73	39	2.00	70	9	9

BASIC SYLLABUS FOR

MATHEMATICS (ENGINEERING) T 111

(One 3-hour paper)

ALGEBRA

Exponentials and logarithms. Definitions, basic theory, change of base, manipulation. Graphs of e^x, e^{-x}, a^x, $\log_e x$. Quadratic equations (no theory): harder problems. Equations involving surds, exponentials and logarithms.

Use of determinants in solving simultaneous equations of second and third order (no theory). Binomial Theorem, positive, negative and fractional indices. $\underset{n \to \infty}{Lt} (1 + 1/n)^n = e$

TRIGONOMETRY

Fundamental identities: derived identities. Equations. Trigonometric ratios of angles of any magnitude including negative angles. Graphs of sin θ, cos θ, tan θ. Inverse trigonometrical ratios of any angle. Graphs of arc sin θ, arc cos θ and arc tan θ. Solution of triangles and applications. Functions of compound angles. Transformation from products to sums and vice versa: multiple and sub-multiple angles. Circular measure: arc, sector and segment. Angular velocity. Sines and cosines of small angles.

$$\underset{\theta \to 0}{Lt} \frac{\sin \theta}{\theta} = 1$$

COMPLEX NUMBERS

Argand diagram, the operator j, modulus and argument, addition and subtraction. Addition, subtraction, multiplication and division by calculation. Polar forms.

DIFFERENTIAL CALCULUS

Meaning of variables, constants, functions, limits, increments, gradients, rates of change. Standard form of derivative. Differentiation from first principles of C, ax^n, e^x, sin θ and cos θ.

Sum, product and quotient rules. Applications: differentiation of simple algebraic functions and the trigonometric functions, tan θ, sec θ, cosec θ and cot θ.

Differentiation of implicit functions. Second and higher order derivatives of simple functions and their meaning.

Simple applications of differentiation. Maxima and minima: simple problems. Curve tracing.

INTEGRAL CALCULUS

Area under a curve by mid-ordinate and Simpson's rules. Integration as the limit of an area and the inverse of differentiation. Integration of functions in first paragraph of preceding section. Definite integrals. Simple applications.

BASIC SYLLABUS FOR

WORKSHOP TECHNOLOGY (M & E) T 111

(One 3-hour paper)

1. SAFETY PRECAUTIONS IN A WORKSHOP

   Clothing, protection against dust: goggles, guards for belts, etc. Electrical switches and starters.

2. PURPOSE OF HAND TOOLS

   such as

   chisels (flat, cross-cut, round nosed, diamond point), files, scrapers, reamers, hacksaw.

3. MEASUREMENT AND MARKING OUT

   Principles and applications of the following:

   Calipers (inside, outside and jennies), dividers, verniers, micrometers (inside, outside and depth), height gauge, protractor, vernier depth gauge, scribing block, angle plate, surface plate, combination square, scriber, prick and centre punches, trammels, Vee-blocks.

4. SCREW THREADS

   Methods of producing: dies and taps, screwcutting on a lathe-gearbox machines only, rolling. (No calculations required).

   Forms and applications of the following threads: S.I., B.A., B.S.F.B.S.P., Unified; American and metric, square, Acme; Buttress, Knuckle.

   The calculation of tapping sizes.

5. JOINING MATERIALS

   The processes of hard and soft soldering; brazing;

making and testing of joints in electrical conductors. Welding: applications and advantages of arc, flame and spot. Precautions in handling and making connections to semi-conductors (heat sinks).

Adhesives used in joining materials and in the building up of laminated structures.

6. <u>SHEET METAL WORK</u>

Simple manipulation of sheet metal; use of bending machines. The fly-press and unit tooling used in chassis manufacture. Gate stop locations and pin punches. Simple drill templates. Blanking and piercing methods. Short run press-tools. The use of epoxy resin for simple form tools.

7. <u>PURPOSE OF THE FOLLOWING MACHING TOOLS</u> (including typical tools used):

Sensitive, pillar and radial drilling machines

Boring machines (mills)

Shaping machines, planers and slotters (no detail of quick return motions for examination purposes)

The centre lathe; simple toolroom; taper turning.

Capstan and turret lathes

Calculation of cutting speeds and feeds.

<u>Note</u>: Workshop Technology is not to be treated in depth as in the case of Trade Theory, Fitting and Turning, which requires a great amount of detail to meet the requirements of the artisan; it is only necessary for technician student to gain an overall idea of the purposes of machine tools, hand tools, equipment and accessories.

BASIC SYLLABUS FOR

ENGINEERING DRAWING T 111

(One 4-hour paper)

1. FREEHAND SKETCHING

   Freehand sketching of screw threads, nuts and bolts, springs, locking devices, shafts, keys and other engineering details.

2. CONSTRUCTIONS

   Ellipse (exact and approximate) parabola and hyperbola; Conic sections, evolute, helix cycloids, spiral.

3. PROJECTION

   Projection of points and lines. Planes, traces, dihedral angle, true length of lines.

4. AUXILIARY PROJECTION

   Making use of first and second auxiliary projections.

5. ISOMETRIC PROJECTION

   Isometric projection of simple solids.

6. INTERSECTION

   Intersection of flat and curved surfaces. Development of three dimensional figures penetrating each other.

7. MACHINE DRAWING

   Drawing of simple machine components (but not assemblies)

8. VECTORS

   Vectors, vector polygon, non-concurrent force systems, Bow's Notation applied to simple frames.

BASIC SYLLABUS FOR

ELECTROTECHNOLOGY (CIVIL) T 111

(One 3-hour paper)

OBJECTIVE: The course is designed to provide theoretical knowledge in sufficient depth to enable the Civil Engineering Technician to supervise the operation of the type of electrical installations and equipment he is likely to meet on a construction site and to co-ordinate civil engineering construction with associated electrical work.

SYLLABUS

1. INTRODUCTION

Simple atomic theory applied to conductors and insulators.
Units of quantity and current; concept of electromotive force (e.m.f.) and potential difference. Concept of power and resistance; units of power and resistance; indications of current and potential difference.
Relationship between voltage and current; Ohm's law; applications.
Sources of e.m.f.; cells in series, parallel, series-parallel.
Resistors in series, parallel and series-parallel; resistivity and conductivity definitions and units; typical practical values; effects of temperature.
Wire gauges and use of tables.

2. MAGNETISM

Properties, characteristics, detection, direction and production of a magnetic field. Force on current-carrying conductor. Unit and definition of flux density. Faraday's and Lenz's Laws, cutting and linking rules. Self and mutual inductance. Concept of growth and decay of current.

Definitions, units and relationships of magnetic field strength, magnetomotive force (m.m.f.). Concept of methods of producing flux; flux density.

3. ALTERNATING CURRENTS

Production of alternating e.m.f. in a coil rotating in a uniform magnetic field; instantaneous e.m.f. equation. Concept of terms; wave form frequency and periodic time. Relationship between pole pairs, speed and frequency. Average and root mean square (r.m.s.) values. Phasor representation, summation of phasors.

Elementary knowledge of R, L and C.

Principles of a.c. generators. Induction Motors. General principles, characteristics and typical performance (descriptive only). Basic connections, starting.

Transformers

Principles of operation of transformers single and three-phase.

Connections; ratios of line voltages and currents; standard terminal markings. Three-phase four-wire systems, earthing of neutral; lighting and power circuits.

Switchgear

Air circuit breakers, description and characteristics of common types.

Fuses.

Instruments

Use of basic instruments, ammeter, voltmeter, ohmmeter and megger in laboratory work.

4. RETICULATION

Consumer's sub-station

Transformers and switchgear. Safety precautions; protective devices.

Distribution boards and metering tariffs

Wiring diagrams and standard symbols

Typical layouts; calculation of cable sizes

Principles of earth leakage protection

Lighting circuits- characteristics of lamps.

NOTES:

Sections 1 and 2: These sections are designed to provide basic principles only and the practical application of formulae. Detailed derivations are not required.

Section 3: This section is designed to cover basic principles only in relation to practical applications. It need provide only knowledge to cover equipment of s size likely to be met on site.

Section 4: This section is designed to provide the trainee with knowledge of the principles relating to the equipment he is likely to meet on site, including the way in which electrical power is likely to be supplied.

It should also cover basic safety and give clear limits of action which may be taken by the supervisor who is not fully electrically qualified.

CONSTRUCTION

Training must be provided to give the trainee an insight into the relationship in programming terms between civil and electrical construction. It should be covered by a project given in-company.

BASIC SYLLABUS FOR

PRINCIPLES OF ELECTRICITY T 111

(One 3-hour paper)

1. ELECTRIC CURRENT

Simple Atomic Theory as applied to conductors and insulators.

2. THE ELECTRIC CIRCUIT

Units of quantity and current; concept of electromotive force (e.m.f.) and potential difference. Concept of power and resistance; units of power and resistance; indication of current and potential difference. Relationship between voltage and current; Ohm's Law; application. Sources of e.m.f. cells in series, parallel and series-parallel, and conditions. Resistors in series, parallel and series-parallel; resistivity and conductivity; units and definitions; typical practical values. Wire gauges and use of tables. Effect of temperature on resistance, resistivity and conductivity; application in electrical circuits. Balanced circuits; potentiometer and Wheatstone bridge; galvanometer. Application for measurement of resistance including substitution method. Use of energy, power and torque units in calculation of efficiency. Electrolysis. Practical primary and secondary cells.

3. MAGNETISM

(a) The Magnetic Field

Properties, characteristics, detection, direction and production. Force on current-carrying conductor. Unit and definition of flux density.

(b) Electromagnetic Induction

Faraday's and Lenz's Laws, cutting and linking rules. Self and mutual inductance; units and definition of flux and inductance. Energy stored and dissipated.

Concept of growth and decay of current. Graphical representation of e.m.f. under varying current conditions.

(c) Magnetic Circuits

Definitions, units and relationships of magnetizing force, magnetomotive force (m.m.f.), reluctance, relative and absolute permeability. Leakage, fringing and useful flux. B/H curve and hysteresis loop. Comparison and application of magnetic properties of iron, steel and alloys.
Hysteresis loss and Steinmetz' empirical law. Construction and use of the fluxmeter. Force exerted by electromagnet on a magnetic material.

4. ELECTROSTATICS

Capacitance, unit and definition; capacitors; in series, parallel and series-parallel combinations; Electric force or potential gradient; electric flux density; permittivity of free space, relative permittivity or dielectric constant; capacitance as dependent upon dimensions of capacitor. Charge and discharge of capacitor; ballistic galvanometer. Energy stored and dissipated; concept of growth and decay of current. Graphical representation of current under varying voltage conditions.

5. ALTERNATING CURRENTS (Sinusoidal only)

Production of alternating e.m.f. in a coil rotated in a uniform magnetic field; instantaneous e.m.f equation. Concept of terms: wave form, frequency and periodic time. Relationship between pole pairs, speed and frequency. Average and root mean square (r.m.s.) values of currents and voltages. Phasor representation. Summation of phasors.

6. MEASURING INSTRUMENTS

Essential features of analogue instruments. Construction and principles of operation of moving coil, moving iron and dynamometer instruments. Sensitivity, Standard markings. Extension of ranges. Ohmmeter and megger. Calibration of ammeters and voltmeters using a potentiometer.

BASIC SYLLABUS FOR

GENERAL STUDIES T 111

COMMUNICATION

(a) Letter, report and verbal media as means of communciation between individual and organisations and between organisations and organisations.

(b) (i) Principles of good letter and report writing using typical and practical examples from the business and technical fields.

(ii) Basis of good presentation in regard to correct headings, references etc. and the orderly presentation of facts or data with accuracy, sequence, brevity and coherence.

(iii) The auxilliary use of diagrams, graphs, charts, photographs and other usual aids to letter and report writing to reduce time in preparation and subsequent reading.

(iv) Advance preparation and summaries made in anticipation of the drafting of an important letter or report, including cross-checking (where possible) of data provided by others. Use of technical libraries or available literature and information on the subject matter under consideration.

(v) Preparation of simple advertising matter and methods of replying to advertisements.

(c) (i) The art of speech delivery from either advance-prepared notes read out (e.g. to technical society meetings, specialised information reports to committees etc.) or extemporaneous

(ii) Initial attendance at public and other meetings to obtain knowledge of, and criticise methods of oral delivery by others.

(c) (iii) The importance of deportment, delivery style and mastery of subject matter.

(iv) Development of theme, with supporting references from other informative sources where desirable and logical argument or explanations as theme progresses.

(v) The conduct of a meeting with explanations regarding preparation of initial notices, agenda and minute-taking. The duties of the "chair" in presentation of progress stages of a meeting in correct order and the handling of questions from, and answers to, the "floor". Winding-up of meeting (votes of thanks and any special announcements re: future meetings etc.).

(vi) The handling of delegations from works or other organised bodies with special regard to minute-taking, observance of decisions or promises made and subsequent "report-back".

BASIC SYLLABUS FOR

APPLIED MECHANICS T111

(One 3-hour paper)

A. GENERAL

1. General Definitions
   Mass, force, particle, rigid body, displacement, equilibrium, resultant, scalars, vectors.
2. Vectors
   Addition of vectors; resolution of vector into components in any two directions; application of vectors to force displacements, velocities (not to include relative velocities).
3. Statics
   Equilibrium of a particle under the action of co-planar forces; parallel forces; moments and couples; replacing a force by a force and a couple; conditions of equilibrium of a body under co-planar forces.
4. Non-Concurrent Forces
   Link polygon and analytical solutions of non-concurrent co-planar forces.
5. Forces in Frameworks
   Analytical determination of forces in frameworks by method of sections, and graphical determination of forces in frameworks by Bow's Notation.
6. Centre of Gravity
   Centroids and centres of gravity of simple laminae and solid-bodies:- square, disc, triangle, rectangle, cone (hollow and solid), hemisphere, pyramid and composite bodies.
7. Friction
   The laws of solid friction; coefficient of friction, angle of friction; friction on an inclined plane.
8. Simple Machines
   Load, effort, mechanical advantage, velocity ratio and efficiency of simple machines; the law of the

8. machine; pulley blocks; inclined plane; wedges; screw; wheel and axle; differential wheel and axle; Weston differential pulley; geared winch; levers; reversibility and limiting efficiency.

9. Elasticity

   Tensile stress and strain; Hooke's Law; modulus of elasticity.

B. <u>DYNAMICS</u>

1. Linear displacement; velocity and acceleration; motion with uniform acceleration; vertical motion under gravity; momentum; Newton's laws of motion; force, mass and acceleration.

2. Work, Energy and Power

   Work done against a resistance or gravity; diagram of work; space average of a force; potential and kinetic energy; the principle of conservation of energy; power; units of work, energy and power. Motion of a body on a rough inclined plane.

3. Angular Motion

   Angular velocity and acceleration; torque; work done by a torque.

BASIC SYLLABUS FOR

APPLIED TECHNOLOGY T 111

(LIGHT CURRENT)

(One 3-hour paper)

1. PASSIVE COMPONENTS

(a) Resistors

Construction of the more common types of resistors, fixed and variable, used in the electronics and radio industries. Production methods. Coding of resistors. Ratings. The effect of temperature on resistors. N.T.C. and V.D.R. resistor types. Reasons for using specific resistor types.

(b) Coils

Methods of construction of power, audio,intermediate and radio frequency coils. Losses; Q factors; winding capacitance; core materials. Coil wire, Doping. Shielding. Effect of saturation on characteristics, method of preventing saturation.

(c) Transformers

Operation and construction of power, audio, intermediate and radio frequency transformers. Core material, winding methods, losses, efficiency. Ratings.

(d) Capacitors

Materials used in the construction of capacitors. Constructional details of fixed and variable capacitors commonly used in the radio and electronics industry. Losses and loss angle. Effect of temperature and frequency. Coding and rating of capacitors. Reasons for using specific capacitor types.

2. CONSTRUCTIONAL COMPONENTS

Plugs, sockets, switches, component terminal boards, stand-off insulators, printed wiring boards.

3. ELECTRO-MECHANICAL DEVICES

Operation and construction of relays, loudspeakers, pick-ups, earphones and microphones. Matching in circuits.

4. BATTERIES AND ACCUMULATORS

All types of generation of an electromotive force by chemical means.

5. THERMIONIC VALVES

Historical development of the pentode valve after the discovery of the Edison effect. Details of construction of the diode and triode (vacuum and gas-filled), tetrode and pentode. Receiving and transmitting valves. Typical practical circuit and applications.

PREDICTOR BATTERY NORMS FOR THE COMBINED ENGLISH GROUP (N=140)

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
445	-2.85	22	0.22	1	1
446	-2.50	25	0.63	1	1
447	-2.25	28	1.24	1	1
448	-2.19	28	1.43	1	1
449	-2.19	28	1.43	1	1
450	-2.19	28	1.43	1	1
451	-2.19	28	1.43	1	1
452	-2.19	28	1.43	1	1
453	-2.19	28	1.43	1	1
454	-2.19	28	1.43	1	1
455	-2.19	28	1.43	1	1
456	-2.19	28	1.43	1	1
457	-2.19	28	1.43	1	1
458	-2.19	28	1.43	1	1
459	-2.19	28	1.43	1	1
460	-2.19	28	1.43	1	1
461	-2.19	28	1.43	1	1
462	-2.19	28	1.43	1	1
463	-2.19	28	1.43	1	1
464	-2.19	28	1.43	1	1
465	-2.19	28	1.43	1	1
466	-2.19	28	1.43	1	1
467	-2.19	28	1.43	1	1
468	-2.15	29	1.60	1	1
469	-2.06	29	1.96	1	1
470	-2.03	30	2.14	1	1
471	-2.03	30	2.14	1	1
472	-2.03	30	2.14	1	1
473	-2.03	30	2.14	1	1
474	-2.03	30	2.14	1	1
475	-2.03	30	2.14	1	1
476	-2.03	30	2.14	1	1
477	-2.03	30	2.14	1	1
478	-1.99	30	2.31	1	1
479	-1.93	31	2.67	1	2
480	-1.88	31	3.03	1	2
481	-1.83	32	3.39	1	2
482	-1.80	32	3.57	1	2
483	-1.80	32	3.57	1	2
484	-1.78	32	3.74	1	2
485	-1.74	33	4.10	2	2
486	-1.70	33	4.46	2	2

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
487	-1.66	33	4.82	2	2
488	-1.65	34	5.00	2	2
489	-1.63	34	5.17	2	2
490	-1.58	34	5.70	2	2
491	-1.53	35	6.24	2	2
492	-1.52	35	6.42	2	2
493	-1.52	35	6.42	2	2
494	-1.52	35	6.42	2	2
495	-1.52	35	6.42	2	2
496	-1.51	35	6.60	2	2
497	-1.47	35	7.13	2	2
498	-1.43	36	7.67	2	3
499	-1.42	36	7.85	2	3
500	-1.40	36	8.03	2	3
501	-1.38	36	8.39	2	3
502	-1.37	36	8.57	2	3
503	-1.36	36	8.75	2	3
504	-1.32	37	9.28	2	3
505	-1.29	37	9.82	2	3
506	-1.28	37	10.00	2	3
507	-1.27	37	10.17	2	3
508	-1.25	37	10.53	2	3
509	-1.24	38	10.71	3	3
510	-1.24	38	10.71	3	3
511	-1.24	38	10.71	3	3
512	-1.24	38	10.71	3	3
513	-1.23	38	10.89	3	3
514	-1.21	38	11.25	3	3
515	-1.20	38	11.43	3	3
516	-1.20	38	11.43	3	3
517	-1.20	38	11.43	3	3
518	-1.20	38	11.60	3	3
519	-1.16	38	12.31	3	3
520	-1.12	39	13.21	3	3
521	-1.10	39	13.57	3	3
522	-1.08	39	13.92	3	3
523	-1.04	40	14.99	3	3
524	-0.98	40	16.25	3	3
525	-0.95	41	17.14	3	4
526	-0.93	41	17.68	3	4
527	-0.92	41	17.86	3	4
528	-0.92	41	17.86	3	4
529	-0.91	41	18.04	3	4

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
530	-0.89	41	18.57	3	4
531	-0.87	41	19.11	3	4
532	-0.86	41	19.47	3	4
533	-0.85	42	19.83	3	4
534	-0.84	42	20.00	3	4
535	-0.84	42	20.00	3	4
536	-0.84	42	20.18	3	4
537	-0.82	42	20.72	3	4
538	-0.79	42	21.43	3	4
539	-0.76	42	22.32	3	4
540	-0.70	43	24.10	4	4
541	-0.63	44	26.43	4	4
542	-0.59	44	27.69	4	4
543	-0.58	44	28.23	4	4
544	-0.56	44	28.94	4	4
545	-0.54	45	29.30	4	4
546	-0.54	45	29.48	4	4
547	-0.52	45	30.01	4	4
548	-0.50	45	30.91	4	4
549	-0.46	45	32.15	4	4
550	-0.42	46	33.76	4	5
551	-0.38	46	35.19	4	5
552	-0.36	46	35.91	4	5
553	-0.34	47	36.62	4	5
554	-0.31	47	37.69	4	5
555	-0.28	47	38.94	4	5
556	-0.25	48	40.19	5	5
557	-0.23	48	40.73	5	5
558	-0.23	48	40.73	5	5
559	-0.23	48	40.91	5	5
560	-0.22	48	41.27	5	5
561	-0.21	48	41.62	5	5
562	-0.20	48	41.98	5	5
563	-0.20	48	42.16	5	5
564	-0.18	48	42.87	5	5
565	-0.14	49	44.30	5	5
566	-0.12	49	45.19	5	5
567	-0.11	49	45.72	5	5
568	-0.08	49	46.62	5	5
569	-0.06	49	47.68	5	5
570	-0.03	50	48.75	5	5
571	-0.01	50	49.64	5	5

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
572	0.02	50	50.71	5	5
573	0.05	51	52.14	5	6
574	0.07	51	52.85	5	6
575	0.08	51	53.21	5	6
576	0.10	51	53.92	5	6
577	0.12	51	54.63	5	6
578	0.14	51	55.52	5	6
579	0.16	52	56.24	5	6
580	0.17	52	56.59	5	6
581	0.18	52	57.13	5	6
582	0.19	52	57.66	5	6
583	0.20	52	58.02	5	6
584	0.21	52	58.38	5	6
585	0.23	52	58.91	5	6
586	0.25	52	59.81	5	6
587	0.27	53	60.70	6	6
588	0.30	53	61.77	6	6
589	0.34	53	63.20	6	6
590	0.37	54	64.27	6	6
591	0.38	54	64.98	6	6
592	0.40	54	65.70	6	6
593	0.43	54	66.59	6	6
594	0.46	55	67.67	6	6
595	0.48	55	68.56	6	6
596	0.51	55	69.63	6	6
597	0.56	56	71.06	6	7
598	0.58	56	71.95	6	7
599	0.59	56	72.13	6	7
600	0.60	56	72.49	6	7
601	0.62	56	73.38	6	7
602	0.65	57	74.28	6	7
603	0.67	57	74.99	6	7
604	0.70	57	75.71	6	7
605	0.72	57	76.42	6	7
606	0.74	57	77.14	6	7
607	0.77	58	78.03	7	7
608	0.81	58	79.11	7	7
609	0.84	58	80.00	7	7
610	0.87	59	80.71	7	7
611	0.89	59	81.25	7	7
612	0.89	59	81.43	7	7
613	0.89	59	81.43	7	7
614	0.89	59	81.43	7	7

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
615	0.90	59	81.60	7	7
616	0.91	59	81.96	7	7
617	0.93	59	82.50	7	7
618	0.98	60	83.58	7	7
619	1.03	60	84.83	7	7
620	1.07	61	85.72	7	8
621	1.09	61	86.25	7	8
622	1.11	61	86.61	7	8
623	1.13	61	87.15	7	8
624	1.17	62	87.86	7	8
625	1.20	62	88.40	7	8
626	1.21	62	88.75	7	8
627	1.24	62	89.29	7	8
628	1.27	63	89.83	8	8
629	1.28	63	90.00	8	8
630	1.30	63	90.37	8	8
631	1.37	64	91.45	8	8
632	1.44	64	92.51	8	8
633	1.47	65	92.86	8	8
634	1.47	65	92.86	8	8
635	1.49	65	93.23	8	8
636	1.55	65	93.94	8	8
637	1.61	66	94.66	8	9
638	1.68	67	95.37	8	9
639	1.72	67	95.72	8	9
640	1.74	67	95.90	8	9
641	1.81	68	96.45	9	9
642	1.91	69	97.16	9	9
643	1.99	70	97.69	9	9
644	2.06	71	98.04	9	10
645	2.15	71	98.40	9	10
646	2.25	72	98.76	9	10
647	2.38	74	99.12	9	10
648	2.45	75	99.29	9	10
649	2.57	76	99.49	9	10

PREDICTOR BATTERY NORMS FOR THE AFRIKAANS GROUP (INCLUDING MATRICULATION MARKS AS PREDICTORS). (N = 50)

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
346	-2.46	25	0.69	1	1
347	-2.19	28	1.42	1	1
348	-2.05	29	2.00	1	1
349	-2.05	29	2.00	1	1
350	-2.05	29	2.00	1	1
351	-2.05	29	2.00	1	1
352	-2.05	29	2.00	1	1
353	-2.05	29	2.00	1	1
354	-2.05	29	2.00	1	1
355	-2.05	29	2.00	1	1
356	-2.05	29	2.00	1	1
357	-2.05	29	2.00	1	1
358	-2.05	29	2.00	1	1
359	-2.05	29	2.00	1	1
360	-2.05	29	2.00	1	1
361	-2.05	29	2.00	1	1
362	-2.05	29	2.00	1	1
363	-2.05	29	2.00	1	1
364	-2.05	29	2.00	1	1
365	-2.05	29	2.00	1	1
366	-2.05	29	2.00	1	1
367	-2.05	29	2.00	1	1
368	-2.05	29	2.00	1	1
369	-2.05	29	2.00	1	1
370	-2.05	29	2.00	1	1
371	-2.05	29	2.00	1	1
372	-2.05	29	2.00	1	1
373	-2.05	29	2.00	1	1
374	-2.05	29	2.00	1	1
375	-2.05	29	2.00	1	1
376	-2.05	29	2.00	1	1
377	-2.05	29	2.00	1	1
378	-2.05	29	2.00	1	1
379	-2.05	29	2.00	1	1
380	-2.05	29	2.00	1	1
381	-2.05	29	2.00	1	1
382	-2.05	29	2.00	1	1
383	-2.05	29	2.00	1	1
384	-2.05	29	2.00	1	1
385	-2.05	29	2.00	1	1
386	-2.05	29	2.00	1	1
387	-2.05	29	2.00	1	1
388	-2.05	29	2.00	1	1

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
389	-2.05	29	2.00	1	1
390	-2.05	29	2.00	1	1
391	-2.05	29	2.00	1	1
392	-2.05	29	2.00	1	1
393	-2.05	29	2.00	1	1
394	-2.05	29	2.00	1	1
495	-2.05	29	2.00	1	1
396	-2.05	29	2.00	1	1
397	-2.05	29	2.00	1	1
398	-2.05	29	2.00	1	1
399	-2.05	29	2.00	1	1
400	-2.05	29	2.00	1	1
401	-2.05	29	2.00	1	1
402	-1.97	30	2.46	1	1
403	-1.82	32	3.47	1	2
404	-1.75	32	4.00	1	2
405	-1.70	33	4.47	2	2
406	-1.60	34	5.48	2	2
407	-1.56	34	6.00	2	2
408	-1.56	34	6.00	2	2
409	-1.52	35	6.48	2	2
410	-1.44	36	7.48	2	3
411	-1.41	36	8.00	2	3
412	-1.34	37	8.96	2	3
413	-1.23	38	10.96	3	3
414	-1.18	38	12.00	3	3
415	-1.18	38	12.00	3	3
416	-1.15	38	12.49	3	3
417	-1.10	39	13.49	3	3
418	-1.08	39	14.00	3	3
419	-1.06	39	14.49	3	3
420	-1.02	40	15.50	3	3
421	-0.99	40	16.00	3	3
422	-0.99	40	16.00	3	3
423	-0.97	40	16.50	3	3
424	-0.93	41	17.50	3	4
425	-0.92	41	18.00	3	4
426	-0.92	41	18.00	3	4
427	-0.92	41	18.00	3	4
428	-0.92	41	18.00	3	4
429	-0.92	41	18.00	3	4
430	-0.90	41	18.50	3	4

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
431	-0.86	41	19.50	3	4
432	-0.84	42	20.00	3	4
433	-0.84	42	20.00	3	4
434	-0.84	42	20.00	3	4
435	-0.84	42	20.00	3	4
436	-0.84	42	20.00	3	4
437	-0.84	42	20.00	3	4
438	-0.82	42	20.50	3	4
439	-0.79	42	21.50	3	4
440	-0.77	42	22.01	3	4
441	-0.77	42	22.01	3	4
442	-0.77	42	22.01	3	4
443	-0.76	42	22.50	3	4
444	-0.72	43	23.51	4	4
445	-0.71	43	24.01	4	4
446	-0.71	43	24.01	4	4
447	-0.69	43	24.51	4	4
448	-0.63	44	26.49	4	4
449	-0.55	44	29.00	4	4
450	-0.52	45	30.01	4	4
451	-0.51	45	30.51	4	4
452	-0.47	45	32.01	4	4
453	-0.43	46	33.51	4	5
454	-0.40	46	34.51	4	5
455	-0.36	46	36.01	4	5
456	-0.32	47	37.52	4	5
457	-0.31	47	38.02	4	5
458	-0.28	47	39.01	4	5
459	-0.23	48	41.01	5	5
460	-0.20	48	42.01	5	5
461	-0.20	48	42.01	5	5
462	-0.20	48	42.01	5	5
463	-0.20	48	42.01	5	5
464	-0.20	48	42.01	5	5
465	-0.20	48	42.01	5	5
466	-0.20	48	42.01	5	5
467	-0.20	48	42.01	5	5
468	-0.19	48	42.51	5	5
469	-0.16	48	43.51	5	5
470	-0.15	48	44.01	5	5
471	-0.14	49	44.51	5	5
472	-0.11	49	45.51	5	5
473	-0.08	49	47.01	5	5

APPENDIX A. 22

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
474	-0.03	50	49.00	5	5
475	0.00	50	50.00	5	5
476	0.01	50	50.50	5	5
477	0.05	51	52.00	5	6
478	0.09	51	53.49	5	6
479	0.10	51	53.99	5	6
480	0.10	51	53.99	5	6
481	0.10	51	53.99	5	6
482	0.10	51	53.99	5	6
483	0.10	51	53.99	5	6
484	0.11	51	54.49	5	6
485	0.14	51	55.49	5	6
486	0.16	52	56.49	5	6
487	0.19	52	57.49	5	6
488	0.20	52	57.99	5	6
489	0.20	52	57.99	5	6
490	0.20	52	57.99	5	6
491	0.20	52	57.99	5	6
492	0.20	52	57.99	5	6
493	0.20	52	57.99	5	6
494	0.21	52	58.49	5	6
495	0.24	52	59.48	5	6
496	0.25	53	59.98	6	6
497	0.25	53	59.98	6	6
498	0.25	53	59.98	6	6
499	0.25	53	59.98	6	6
500	0.25	53	59.98	6	6
501	0.25	53	59.98	6	6
502	0.25	53	59.98	6	6
503	0.25	53	59.98	6	6
504	0.25	53	59.98	6	6
505	0.25	53	59.98	6	6
506	0.25	53	59.98	6	6
507	0.25	53	59.98	6	6
508	0.25	53	59.98	6	6
509	0.27	53	60.48	6	6
510	0.29	53	61.48	6	6
511	0.31	53	61.98	6	6
512	0.32	53	62.48	6	6
513	0.34	53	63.48	6	6
514	0.36	54	63.98	6	6
515	0.36	54	63.98	6	6

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
516	0.36	54	63.98	6	6
517	0.36	54	63.98	6	6
518	0.36	54	63.98	6	6
519	0.36	54	63.98	6	6
520	0.36	54	63.98	6	6
521	0.36	54	63.98	6	6
522	0.36	54	63.98	6	6
523	0.36	54	63.98	6	6
524	0.36	54	63.98	6	6
525	0.36	54	63.98	6	6
526	0.37	54	64.48	6	6
527	0.40	54	65.49	6	6
528	0.41	54	65.98	6	6
529	0.41	54	65.98	6	6
530	0.43	54	66.49	6	6
531	0.47	55	67.99	6	6
532	0.51	55	69.49	6	6
533	0.52	55	69.99	6	6
534	0.52	55	69.99	6	6
535	0.54	55	70.49	6	6
536	0.57	56	71.49	6	7
537	0.58	56	71.99	6	7
538	0.58	56	71.99	6	7
539	0.60	56	72.49	6	7
540	0.63	56	73.49	6	7
541	0.64	56	73.99	6	7
542	0.64	56	73.99	6	7
543	0.64	56	73.99	6	7
544	0.64	56	73.99	6	7
545	0.64	56	73.99	6	7
546	0.64	56	73.99	6	7
547	0.64	56	73.99	6	7
548	0.64	56	73.99	6	7
549	0.64	56	73.99	6	7
550	0.64	56	73.99	6	7
551	0.64	56	73.99	6	7
552	0.64	56	73.99	6	7
553	0.66	57	74.49	6	7
554	0.69	57	75.49	6	7
555	0.71	57	75.99	6	7
556	0.71	57	75.99	6	7
557	0.72	57	76.49	6	7
558	0.76	58	77.50	7	7

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
559	0.79	58	78.50	7	7
560	0.82	58	79.50	7	7
561	0.84	58	80.00	7	7
562	0.84	58	80.00	7	7
563	0.84	58	80.00	7	7
564	0.86	59	80.50	7	7
565	0.90	59	81.50	7	7
566	0.93	59	82.50	7	7
567	0.97	60	83.50	7	7
568	0.99	60	84.00	7	7
569	1.02	60	84.50	7	7
570	1.08	61	86.03	7	8
571	1.15	62	87.51	7	8
572	1.18	62	88.00	7	8
573	1.18	62	88.00	7	8
574	1.18	62	88.00	7	8
575	1.18	62	88.00	7	8
576	1.18	62	88.00	7	8
577	1.18	62	88.00	7	8
578	1.18	62	88.00	7	8
579	1.20	62	88.51	7	8
580	1.25	63	89.51	8	8
581	1.28	63	90.00	8	8
582	1.28	63	90.00	8	8
583	1.28	63	90.00	8	8
584	1.28	63	90.00	8	8
585	1.28	63	90.00	8	8
586	1.28	63	90.00	8	8
587	1.31	63	90.51	8	8
588	1.37	64	91.51	8	8
589	1.41	64	92.00	8	8
590	1.41	64	92.00	8	8
591	1.44	64	92.52	8	8
592	1.52	65	93.52	8	8
593	1.56	66	94.00	8	9
594	1.60	66	94.52	8	9
595	1.76	68	96.11	9	9
596	1.97	70	97.54	9	9
597	2.05	71	98.00	9	10
598	2.05	71	98.00	9	10
599	2.05	71	98.00	9	10
600	2.05	71	98.00	9	10

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
601	2.05	71	98.00	9	IO
602	2.05	71	98.00	9	IO
603	2.05	71	98.00	9	IO
604	2.05	71	98.00	9	IO
605	2.05	71	98.00	9	IO
606	2.05	71	98.00	9	IO
607	2.05	71	98.00	9	IO
608	2.05	71	98.00	9	IO
609	2.05	71	98.00	9	IO
610	2.05	71	98.00	9	IO
611	2.05	71	98.00	9	IO
612	2.05	71	98.00	9	IO
613	2.05	71	98.00	9	IO
614	2.05	71	98.00	9	IO
615	2.05	71	98.00	9	IO
616	2.05	71	98.00	9	IO
617	2.05	71	98.00	9	IO
618	2.05	71	98.00	9	IO
619	2.05	71	98.00	9	IO
620	2.05	71	98.00	9	IO
621	2.05	71	98.00	9	IO
622	2.05	71	98.00	9	IO
623	2.05	71	98.00	9	IO
624	2.05	71	98.00	9	IO
625	2.05	71	98.00	9	IO
626	2.05	71	98.00	9	IO
627	2.05	71	98.00	9	IO
628	2.05	71	98.00	9	IO
629	2.05	71	98.00	9	IO
630	2.05	71	98.00	9	IO
631	2.05	71	98.00	9	IO
632	2.05	71	98.00	9	IO
633	2.05	71	98.00	9	IO
634	2.05	71	98.00	9	IO
635	2.05	71	98.00	9	IO
636	2.05	71	98.00	9	IO
637	2.05	71	98.00	9	IO
638	2.05	71	98.00	9	IO
639	2.05	71	98.00	9	IO
640	2.05	71	98.00	9	IO
641	2.05	71	98.00	9	IO
642	2.05	71	98.00	9	IO
643	2.05	71	98.00	9	IO
644	2.05	71	98.00	9	10
645	2.19	72	98.58	9	10

PREDICTOR BATTERY NORMS FOR THE AFRIKAANS GROUP (EXCLUDING MATRICULATION MARKS AS PREDICTORS) (N = 50)

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
409	-2.48	25	0.66	1	1
410	-2.21	28	1.37	1	1
411	-2.07	29	1.92	1	1
412	-2.07	29	1.92	1	1
413	-2.07	29	1.92	1	1
414	-2.07	29	1.92	1	1
415	-2.07	29	1.92	1	1
416	-2.07	29	1.92	1	1
417	-2.07	29	1.92	1	1
418	-2.07	29	1.92	1	1
419	-2.07	29	1.92	1	1
420	-2.07	29	1.92	1	1
421	-1.92	31	2.74	1	2
422	-1.67	33	4.73	2	2
423	-1.57	34	5.77	2	2
424	-1.57	34	5.77	2	2
425	-1.57	34	5.77	2	2
426	-1.57	34	5.77	2	2
427	-1.47	35	7.10	2	2
428	-1.28	37	10.02	2	3
429	-1.20	38	11.54	3	3
430	-1.20	38	11.54	3	3
431	-1.20	38	11.54	3	3
432	-1.20	38	11.54	3	3
433	-1.17	38	12.01	3	3
434	-1.13	39	12.97	3	3
435	-1.10	39	13.46	3	3
436	-1.10	39	13.46	3	3
437	-1.10	39	13.46	3	3
438	-1.10	39	13.46	3	3
439	-1.06	39	14.40	3	3
440	-0.98	40	16.33	3	3
441	-0.94	41	17.31	3	4
442	-0.94	41	17.31	3	4
443	-0.94	41	17.31	3	4
444	-0.94	41	17.31	3	4
445	-0.92	41	17.79	3	4
446	-0.89	41	18.75	3	4
447	-0.87	41	19.23	3	4
448	-0.87	41	19.23	3	4
449	-0.87	41	19.23	3	4
450	-0.87	41	19.23	3	4

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
451	-0.84	42	20.18	3	4
452	-0.77	42	22.11	3	4
453	-0.74	43	23.08	4	4
454	-0.74	43	23.08	4	4
455	-0.74	43	23.08	4	4
456	-0.74	43	23.08	4	4
457	-0.65	44	25.89	4	4
458	-0.48	45	31.69	4	4
459	-0.40	46	34.63	4	5
460	-0.40	46	34.63	4	5
461	-0.40	46	34.63	4	5
462	-0.40	46	34.63	4	5
463	-0.36	46	36.06	4	5
464	-0.28	47	38.95	4	5
465	-0.24	48	40.40	5	5
466	-0.24	48	40.40	5	5
467	-0.24	48	40.40	5	5
468	-0.24	48	40.40	5	5
469	-0.22	48	41.36	5	5
470	-0.17	48	43.28	5	5
471	-0.14	49	44.24	5	5
472	-0.14	49	44.24	5	5
473	-0.14	49	44.24	5	5
474	-0.14	49	44.24	5	5
475	-0.12	49	45.20	5	5
476	-0.07	49	47.12	5	5
477	-0.05	50	48.08	5	5
478	-0.05	50	48.08	5	5
479	-0.05	50	48.08	5	5
480	-0.05	50	48.08	5	5
481	-0.04	50	48.56	5	5
482	-0.01	50	49.52	5	5
483	0.00	50	50.00	5	5
484	0.00	50	50.00	5	5
485	0.00	50	50.00	5	5
586	0.00	50	50.00	5	5
487	0.05	50	51.92	5	5
488	0.14	51	55.76	5	6
489	0.19	52	57.68	5	6
480	0.19	52	57.68	5	6
491	0.19	52	57.68	5	6
492	0.19	52	57.68	5	6
493	0.23	52	59.13	5	6

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
494	0.31	53	62.01	6	6
495	0.34	53	63.44	6	6
496	0.34	53	63.44	6	6
497	0.34	53	63.44	6	6
498	0.34	53	63.44	6	6
499	0.36	54	63.93	6	6
500	0.38	54	64.89	6	6
501	0.40	54	65.37	6	6
502	0.40	54	65.37	6	6
503	0.40	54	65.37	6	6
504	0.40	54	65.37	6	6
505	0.42	54	66.34	6	6
506	0.47	55	68.26	6	6
507	0.50	55	69.22	6	6
508	0.50	55	69.22	6	6
509	0.50	55	69.22	6	6
510	0.50	55	69.22	6	6
511	0.50	55	69.22	6	6
512	0.50	55	69.22	6	6
513	0.50	55	69.22	6	6
514	0.50	55	69.22	6	6
515	0.50	55	69.22	6	6
516	0.50	55	69.22	6	6
517	0.54	55	70.68	6	6
518	0.63	56	73.57	6	7
519	0.67	57	74.99	6	7
520	0.67	57	74.99	6	7
521	0.67	57	74.99	6	7
522	0.67	57	74.99	6	7
523	0.67	57	74.99	6	7
524	0.67	57	74.99	6	7
525	0.67	57	74.99	6	7
526	0.67	57	74.99	6	7
527	0.67	57	74.99	6	7
528	0.67	57	74.99	6	7
529	0.69	57	75.47	6	7
530	0.72	57	76.44	6	7
531	0.74	57	76.92	6	7
532	0.74	57	76.92	6	7
533	0.74	57	76.92	6	7
534	0.74	57	76.92	6	7
535	0.77	58	77.89	7	7

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
536	0.84	58	79.82	7	7
537	0.87	59	80.77	7	7
538	0.87	59	80.77	7	7
539	0.87	59	80.77	7	7
540	0.87	59	80.77	7	7
541	0.87	59	80.77	7	7
542	0.87	59	80.77	7	7
543	0.87	59	80.77	7	7
544	0.87	59	80.77	7	7
545	0.87	59	80.77	7	7
546	0.87	59	80.77	7	7
547	0.89	59	81.25	7	7
548	0.92	59	82.21	7	7
549	0.94	59	82.69	7	7
550	0.94	59	82.69	7	7
551	0.94	59	82.69	7	7
552	0.94	59	82.69	7	7
553	0.96	60	83.18	7	7
554	1.00	60	84.14	7	7
555	1.02	60	84.61	7	7
556	1.02	60	84.61	7	7
557	1.02	60	84.61	7	7
558	1.02	60	84.61	7	7
559	1.06	61	85.60	7	8
560	1.15	62	87.53	7	8
561	1.20	62	88.46	7	8
562	1.20	62	88.46	7	8
563	1.20	62	88.46	7	8
564	1.20	62	88.46	7	8
565	1.20	62	88.46	7	8
566	1.20	62	88.46	7	8
567	1.20	62	88.46	7	8
568	1.20	62	88.46	7	8
569	1.20	62	88.46	7	8
570	1.20	62	88.46	7	8
571	1.20	62	88.46	7	8
572	1.20	62	88.46	7	8
573	1.20	62	88.46	7	8
574	1.20	62	88.46	7	8
575	1.20	62	88.46	7	8
576	1.20	62	88.46	7	8
577	1.22	62	88.95	7	8
578	1.28	63	89.92	8	8

RAW SCORE	UNIT NORMAL SCORE	STANDARD SCORE	PERCENTILE RANK	STANINE	STEN
579	1.30	63	90.39	8	8
580	1.30	63	90.39	8	8
581	1.30	63	90.39	8	8
582	1.30	63	90.39	8	8
583	1.33	63	90.88	8	8
584	1.39	64	91.84	8	8
585	1.43	64	92.31	8	8
586	1.43	64	92.31	8	8
587	1.43	64	92.31	8	8
588	1.43	64	92.31	8	8
589	1.55	65	93.89	8	8
590	1.87	69	96.91	9	9
591	2.07	71	98.08	9	IO
592	2.07	71	98.08	9	IO
593	2.07	71	98.08	9	IO
594	2.07	71	98.08	9	IO
595	2.21	72	98.63	9	IO

INTERCORRELATIONS FOR AFRIKAANS GROUP (UNEQUAL N)

VARIABLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 MA	-																				
2 BLOX	57	-																			
3 DRAT	45	21	-																		
4 SK	46	28	15	-																	
5 TRC	40	18	38	52	-																
6 GFT	62	46	25	49	26	-															
7 GENSTUD*	30	02	32	27	31	36	-														
8 MATHS*	33	17	27	17	17	31	39	-													
9 ENGDRAW*	25	38	15	09	07	50	15	34	-												
10 COMCRSAV*	36	24	27	19	18	52	58	81	64	-											
11 OCCUP	31	13	23	23	11	-04	-08	15	-07	-00	-										
12 PLACE	05	-01	09	02	-07	04	05	-15	-17	-10	-05	-									
13 FAIL	05	06	-11	12	-08	18	-17	-10	08	-10	08	-05	-								
14 MAV	18	11	-03	02	04	08	06	13	11	23	-10	04	-16	-							
15 MM	-03	-09	-07	-14	-13	-10	-15	14	05	16	-12	-01	01	62	-						
16 MS	21	-03	07	27	15	09	07	04	-20	-00	18	14	-06	49	32	-					
17 ME	32	22	15	08	12	11	05	-04	02	-00	20	13	-10	11	00	-08	-				
18 MAF	12	19	06	11	13	-04	10	-04	-02	02	08	12	-15	07	-04	-15	76	-			
19 BEST	01	00	09	10	21	05	10	-06	-11	-11	-09	02	01	-16	-29	-08	15	07	-		
20 LEAST	05	00	-05	13	23	00	18	-17	-22	-23	-15	25	-08	-10	-06	10	07	09	24	-	
21 P TECH	25	09	21	09	39	+	18	10	12	08	02	13	-09	02	08	02	09	04	14	40	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

\+ No figure available.

* Criteria.

NOTE:

1. Ommited from each correlation:0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

APPENDIX A.24

INTERCORRELATIONS FOR AFRIKAANS GROUP (INTAKES 2 AND 3) (N=50)

VARIABLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 MA	-																				
2 BLOX	61	-																			
3 DRAT	32	18	-																		
4 SK	40	24	04	-																	
5 TRC	32	13	15	48	-																
6 GFT	62	46	25	49	26	-															
7 GENSTUD*	16	07	22	21	37	36	-														
8 MATHS*	30	13	14	23	13	31	39	-													
9 ENGDRAW*	26	44	28	21	07	50	23	29	-												
10 COMCRSAV*	35	29	27	29	22	52	64	84	69	-											
11 OCCUP	07	-11	16	16	01	-04	-31	-01	-19	-18	-										
12 PLACE	07	-06	20	-04	-19	04	02	-13	-13	-13	-01	-									
13 FAIL	16	13	-09	04	-10	18	-21	-10	15	-05	06	-04	-								
14 MAV	09	11	-13	16	28	08	18	26	26	33	-07	-06	-20	-							
15 MM	-03	-10	-21	05	-04	-10	-01	39	05	25	00	-10	-03	43	-						
16 MS	06	-01	-02	11	24	09	-07	17	01	08	12	-05	-14	55	46	-					
17 ME	32	20	-02	17	02	11	-01	-28	-18	-25	19	13	-16	10	-11	-07	-				
18 MAF	08	16	-11	26	04	-04	09	-22	-18	-18	08	16	-25	10	-15	-08	78	-			
19 BEST	08	03	06	07	17	05	02	-20	-06	-14	-10	-03	-14	-13	-25	-12	16	06	-		
20 LEAST	14	11	-15	-00	-05	00	13	09	-17	02	02	08	-36	02	17	04	28	34	09	-	
21 P TECH	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

\+ No figure available.

* Criteria.

NOTE:

1. Ommited from each correlation: 0.

2. See Table 6.2 for abbreviations of variables.

3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR COMBINED ENGLISH GROUP (UNEQUAL N)

VARIABLE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1 MA	-																				
2 BLOX	43	-																			
3 DRAT	49	44	-																		
4 SK	48	23	25	-																	
5 TRC	56	25	40	56	-																
6 GFT	47	33	18	19	35	-															
7 GENSTUD*	31	15	11	28	29	20	-														
8 MATHS*	32	08	15	26	18	-10	26	-													
9 ENGDRAW*	21	29	14	05	12	27	09	29	-												
10 COMCRSAV*	38	24	16	27	24	11	48	84	66	-											
11 OCCUP	14	13	08	31	06	04	16	10	-03	07	-										
12 PLACE	13	14	16	07	06	06	-07	10	09	09	-08	-									
13 FAIL	-21	-10	-17	-18	-28	-17	-11	-20	-14	-23	13	-19	-								
14 MAV	19	05	12	30	34	-02	19	15	09	19	-10	07	-17	-							
15 MM	09	00	06	03	-00	-01	-02	15	07	13	07	18	-12	43	-						
16 MS	12	13	20	07	04	-07	07	17	10	18	-10	16	-16	44	36	-					
17 ME	27	10	17	32	31	01	33	20	-03	19	16	13	-30	23	13	16	-				
18 MAF	09	04	06	13	16	-02	27	15	-01	16	-05	08	-17	-12	-24	-04	40	-			
19 BEST	-02	-01	02	00	05	06	10	-11	-24	-15	05	-03	02	-14	-18	-28	14	20	-		
20 LEAST	12	10	08	04	04	02	08	04	-10	-03	-03	02	-18	11	07	24	15	04	-05	-	
21 P TECH	06	-01	04	06	04	-07	-06	06	-04	01	01	-09	-12	-00	02	19	18	11	-14	04	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

* Criteria.

NOTE:

1. Ommited from each correlation: 0.

2. See Table 6.2 for abbreviations of variables.

3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

APPENDIX A.26

INTERCORRELATIONS FOR MECHANICAL GROUP (UNEQUAL N)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 MA	-																					
2 BLOX	49	-																				
3 DRAT	55	77	-																			
4 SK	46	29	37	-																		
5 TRC	58	31	34	75	-																	
6 GFT	57	29	36	50	61	-																
7 GENSTUD*	31	07	14	43	28	10	-															
8 MATHS*	17	02	-08	25	06	-29	52	-														
9 ENGDRAW*	27	26	20	20	23	23	46	33	-													
10 COURSAV*	29	14	06	33	25	-06	71	84	67	-												
11 COMCRSAV*	30	15	09	34	21	-04	74	83	77	95	-											
12 OCCUP	29	17	26	47	10	-06	30	12	-16	04	06	-										
13 PLACE	-26	-01	-12	-02	-04	-15	-21	08	-09	-01	-05	-34	-									
14 FAIL	-34	-24	-17	-40	-35	-23	-24	-27	-38	-41	-39	07	-09	-								
15 MAV	-07	11	09	33	19	09	04	-01	09	06	04	12	19	-10	-							
16 MM	-20	05	-04	02	-05	-28	-20	-16	-05	-17	-16	17	15	-05	42	-						
17 MS	05	21	29	-08	-18	-21	-14	07	-01	-05	-00	-06	26	-10	26	21	-					
18 ME	31	25	21	26	14	04	35	33	10	31	31	19	20	-32	-02	-01	21	-				
19 MAF	18	-07	-03	18	04	-16	32	55	-06	36	35	-01	22	-27	-29	-28	-04	43	-			
20 BEST	03	-18	-16	-04	03	28	01	-19	-37	-27	-28	12	-09	-00	-34	-20	-28	04	12	-		
21 LEAST	33	28	19	03	-02	11	-04	27	08	16	17	04	-00	-02	-13	-05	25	27	35	-23	-	
22 P TECH	30	17	22	11	01	-15	19	28	18	23	29	10	-07	-31	-24	-06	31	49	30	-14	37	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

* Criteria.

NOTE:

1. Ommited from each correlation: 0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR ELECTRICAL GROUP (UNEQUAL N)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 MA	-																					
2 BLOX	46	-																				
3 DRAT	47	32	-																			
4 SK	45	14	15	-																		
5 TRC	58	18	41	56	-																	
6 GFT	59	45	20	18	36	-																
7 GENSTUD*	32	25	14	26	41	30	-															
8 MATHS*	22	02	23	12	09	-12	09	-														
9 ENGDRAW*	25	32	14	08	-01	27	02	37	-													
10 COURSAV*	31	11	20	29	24	02	30	85	58	-												
11 COMCRSAV*	34	22	25	18	15	-09	31	88	71	92	-											
12 OCCUP	06	08	10	12	15	09	15	-10	11	08	02	-										
13 PLACE	25	18	11	16	17	36	20	24	29	32	34	13	-									
14 FAIL	-18	-00	-15	-24	-33	-05	-13	-26	-11	-32	-26	21	-22	-								
15 MAV	37	01	13	32	48	16	20	27	09	33	28	-35	10	-34	-							
16 MM	20	-02	11	-01	15	27	-03	27	11	25	22	-07	22	-24	45	-						
17 MS	23	08	01	23	34	18	11	31	17	42	32	00	18	-23	67	42	-					
18 ME	25	-01	11	48	53	07	38	09	-17	16	08	07	16	-37	45	22	06	-				
19 MAF	02	-07	05	20	24	-03	33	-04	-14	-04	-01	-04	04	-18	-08	-23	-27	46	-			
20 BEST	-01	08	05	02	10	09	12	-02	-15	-07	-06	-04	-02	09	-11	-17	-29	22	46	-		
21 LEAST	03	-06	-01	02	13	-06	-06	-10	-22	-06	-18	-01	10	-30	16	06	21	07	-11	-03	-	
22 P TECH	-10	-16	-08	06	-01	-21	-26	-07	-24	-15	-22	01	-22	03	18	07	19	-00	-01	-10	-05	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined

* Criteria.

NOTE:

1. Ommited from each correlation: 0.
2. See Table G.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR CIVIL GROUP (UNEQUAL N)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1 MA	-																					
2 BLOX	36	-																				
3 DRAT	45	37	-																			
4 SK	62	33	28	-																		
5 TRC	52	31	44	36	-																	
6 GFT	15	22	-02	-12	11	-																
7 GENSTUD*	33	10	10	24	21	13	-															
8 MATHS*	59	24	16	48	40	09	33	-														
9 ENGDRAW*	19	29	16	-05	24	34	-18	26	-													
10 COURSAV*	55	35	20	46	44	07	42	84	33	-												
11 COMCRSAV*	53	36	11	37	40	27	43	87	51	90	-											
12 OCCUP	05	11	-07	42	-02	04	05	26	-04	05	10	-										
13 PLACE	27	21	38	09	01	-13	-23	-05	05	-10	-10	-11	-									
14 FAIL	-12	-12	-21	11	-14	-27	05	-04	05	-06	-01	17	-24	-								
15 MAV	22	08	18	24	32	-42	34	15	07	34	23	-06	-06	05	-							
16 MM	19	-02	10	15	-18	-18	12	29	09	27	28	10	16	02	42	-						
17 MS	16	14	33	02	-05	-10	26	17	19	31	29	-15	13	-20	39	52	-					
18 ME	19	10	21	16	20	-24	40	20	06	28	21	26	-06	-13	48	27	35	-				
19 MAF	03	38	17	-09	16	20	20	-06	34	11	21	-12	-02	-01	13	-17	29	10	-			
20 BEST	-06	02	12	05	04	-21	14	-13	-26	-06	-17	04	01	-05	04	-21	-29	23	-07	-		
21 LEAST	19	19	15	04	-05	-01	32	12	-11	19	06	-02	02	-17	15	20	18	33	-01	08	-	
22 P TECH	-06	03	-01	02	24	29	-05	-03	04	-05	00	-19	08	-17	-05	+	+	-25	00	-29	-14	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

+ No figure available.

* Criteria.

NOTE:

1. Ommited from each correlation:0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR MECHANICAL GROUP (N=33)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13
1 FAIL	-												
2 MM	-01	-											
3 MS	-14	13	-										
4 ME	-12	09	30	-									
5 MAF	-23	03	05	02	-								
6 MA	-25	-29	-12	37	-10	-							
7 BLOX	-19	-07	07	15	-29	45	-						
8 DRAT	03	-22	04	09	-24	46	69	-					
9 SK	-31	-12	02	40	09	43	23	30	-				
10 TRC	-26	-24	-02	28	07	61	30	29	69	-			
11 COURSAV*	-32	-21	03	12	29	21	15	-02	25	13	-		
12 COMCRSAV*	-33	-15	-00	07	22	23	17	03	32	17	95	-	
13 CRSPASSD*	-20	-21	-06	-05	36	09	13	-01	08	02	93	88	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

* Criteria.

NOTE:

1. Ommited from each correlation:0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR ELECTRICAL GROUP (N = 60)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13
1 FAIL	-												
2 MM	-24	-											
3 MS	-28	52	-										
4 ME	-17	15	41	-									
5 MAF	-18	05	21	53	-								
6 MA	-09	20	17	29	21	-							
7 BLOX	03	-05	-02	-01	02	44	-						
8 DRAT	-10	15	03	-04	-07	43	30	-					
9 SK	-12	-11	27	35	33	43	13	11	-				
10 TRC	-30	15	40	57	42	55	13	36	51	-			
11 COURSAV*	-22	25	35	10	12	23	05	17	26	19	-		
12 COMCRSAV*	-17	27	25	00	10	28	18	23	15	11	91	-	
13 CRSPASSD*	-19	15	29	08	05	22	07	14	25	14	85	77	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

* Criteria.

NOTE:

1. Ommited from each correlation:0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR CIVIL GROUP (N= 47)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13
1 FAIL	-												
2 MM	09	-											
3 MS	-04	53	-										
4 ME	-15	27	41	-									
5 MAF	03	-13	16	08	-								
6 MA	-14	24	29	17	07	-							
7 BLOX	-10	07	16	11	34	37	-						
8 DRAT	-16	06	23	21	10	49	37	-					
9 SK	09	19	18	15	01	63	43	38	-				
10 TRC	-16	-08	14	27	19	53	29	56	33	-			
11 COURSAV*	-04	28	40	26	14	55	36	20	51	48	-		
12 COMCRSAV*	04	31	31	19	17	54	33	09	46	42	91	-	
13 CRSPASSD*	06	21	20	19	14	57	32	25	57	49	83	80	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

* Criteria.

NOTE:

1. Ommited from each correlation: 0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR COMBINED ENGLISH GROUP (N= 140)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12
1 FAIL	-											
2 MM	-05	-										
3 MS	-17	53	-									
4 ME	-14	23	38	-								
5 MAF	-10	08	31	39	-							
6 MA	-16	03	11	21	10	-						
7 BLOX	-09	-05	05	01	04	44	-					
8 DRAT	-07	02	08	00	-03	41	33	-				
9 SK	-09	04	24	29	23	46	22	21	-			
10 TRC	-24	-02	22	20	23	55	24	37	50	-		
11 COMCRSAV*	-21	08	14	07	11	36	25	11	25	21	-	
12 CRSPASSD*	-16	01	12	04	10	32	18	14	28	23	81	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

* Criteria.

NOTE:

1. Ommited from each correlation: 0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

INTERCORRELATIONS FOR AFRIKAANS GROUP (INTAKES 2 AND 3) (N=50)

VARIABLES	1	2	3	4	5	6	7	8	9	10	11	12	13
1 GFT	-												
2 MA	62	-											
3 BLOX	46	61	-										
4 DRAT	25	32	18	-									
5 SK	49	40	24	04	-								
6 TRC	26	32	13	15	48	-							
7 MM	-10	-03	-10	-21	05	-04	-						
8 MS	09	06	-01	-02	11	24	46	-					
9 ME	11	32	20	-02	17	02	-11	-07	-				
10 MAF	-04	08	16	-11	26	04	-15	-08	78	-			
11 FAIL	18	16	13	-09	04	-10	-03	-14	-16	-25	-		
12 CRSPASSD*	<u>44</u>	27	23	20	30	<u>33</u>	08	14	-20	-19	-08	-	
13 COMCRSAV*	<u>52</u>	<u>35</u>	29	27	29	<u>22</u>	25	08	-25	-18	-05	80	-

Correlations which are significantly different from a zero correlation (at the one percent confidence level) are underlined.

* Criteria

NOTE:

1. Ommited from each correlation: 0.
2. See Table 6.2 for abbreviations of variables.
3. Only predictor and criteria significances were checked. Chance factors could be expected to yield one significant difference per hundred correlations.

APPENDIX A.34

Identification Number [ ]

NATIONAL INSTITUTE FOR PERSONNEL RESEARCH

BIOGRAPHICAL QUESTIONNAIRE

INSTRUCTIONS

i) Answer all questions as comprehensively as possible. Your answers will be treated confidentially.

ii) In many cases it is necessary merely to put a cross (x) in the appropriate block.

iii) Please print your answers.

QUESTIONNAIRE

1. Surname:____

2. Christian Name(s):_____________________________________

3. Today's date: Day: Month: Year:

4. Date of birth: Day: Month: Year:

5. Age (in years and full months): Years: Months:

6. Home Language: English Other (Specify)

7. Place a cross (x) in the appropriate block.

(a) How many children (yourself, stepbrothers and half-brothers, stepsisters and halfsisters and adopted children included) are there in your family?

One [ ]

Two [ ]

Three [ ]

Four [ ]

Five [ ]

Six or more [ ]

(b) Are you the

First [ ]

Second [ ]

Third [ ]

7. (b) Are you the

Fourth______________________ [ ]

Fifth______________________ [ ]

Sixth or after______________ [ ]

child in the family (stepbrothers and halfbrothers, stepsisters and halfsisters and adopted children included)?

8. What is your father's educational standard?

Std. 8 or less__________________ [ ]

Std. 9___________________________ [ ]

Std. 10__________________________ [ ]

Post-matric (degree excluded)____ [ ]

University degree_______________ [ ]

9. What is your mother's educational standard?

Std. 8 or less__________________ [ ]

Std. 9___________________________ [ ]

Std. 10__________________________ [ ]

Post-matric (degree excluded)____ [ ]

University degree_______________ [ ]

10. What is your father's present occupation?

____

____

11. What career would your parents like you to follow?

____

____

12. Type of school where you matriculated?

Academic school________________ [ ]

Technical school_______________ [ ]

Agricultural school____________ [ ]

Commercial school______________ [ ]

13. Where is the school situated?

City or urban area______________ [ ]

Small town or rural area_________ [ ]

14. In which language medium were you taught?

English_________________________ [ ]

English and Afrikaans___________ [ ]

Afrikaans_______________________ [ ]

Other language__________________ [ ]

15. How many times did you fail a standard?

Never failed____________________ [ ]

Failed once_____________________ [ ]

Failed two or more times_________ [ ]

16. Write down all the subjects that you studied in Std. 10. Indicate next to each subject the percentage of symbol that you obtained for that subject in the final examination.

	Std. 10 Subjects	Percentage/ Symbol
1		
2		
3		
4		
5		
6		
7		

17. Class of pass

First class_______ [ ]

Second class______ [ ]

18. (a) Write down the two subjects that you enjoyed the most.

i)______________________

ii)______________________

18. (b) Write down the two subjects that you enjoyed the least.

(i) ________________________________

(ii) ________________________________

19. Indicate for which of the following engineering technician courses you have enrolled.

Mechanical engineering______________ [ ]

Civil engineering__________________ [ ]

Electrical engineering(light current) [ ]

20. In which language medium will you receive instruction during the course?

English__________________ [ ]

Afrikaans_________________ [ ]

21. Are you enrolled for the pre-technician course this term? | Yes | No |

22. Have you received the pre-technician course during a previous term? | Yes | No |

23. (a) Have you received any further training since leaving school apart from the engineering technician course? | Yes | No |

(b) If "yes" please provide the following particulars:

	NAME OF COURSE	Length of course (in years)	Number of years successfully completed
1			
2			
3			
4			
5			
6			

24. (a) Have you ever worked full-time before you enrolled at the Technikon?

Yes	No

(b) If "Yes" provide particulars below.

	Name of Employer	Job Title	Length of Service (in months)
1			
2			
3			
4			
5			
6			

(c) If "Yes"have any of the jobs you have done before given you experience or training which is relevant to the course for which you have enrolled? Please provide details below.

	Job Title	Type of Work	Duration of job (months)
1			
2			
3			
4			
5			
6			

25. Name of organisation where you received your practical training.

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26. Below are listed 10 possible reasons for choosing a career.

1. Provide me with the opportunity for earning a good income.
2. Give me social status and prestige.
3. Allow me to be physically active.
4. Assure me a stable and secure future.
5. Allow me to use my best abilities and aptitudes.
6. Give me a chance to exercise leadership.
7. To do work which is always varied and interesting.
8. To be of service to the community.
9. To play an important role in the development of the environment.
10. To do work which is too difficult for most people.

(a) Which of the above reasons do you regard as the most important in your choice of career as engineering technician? Write the number that appears next to the reason you have selected in this block. [ ]

(b) Write the numbers of other reasons listed above that you regard as important ______________________

(c) Write the number of the reason that you regard as least important in this block. [ ]

27. What was the most important source of information about the career of engineering technician that influenced your choice of this career (e.g. which person, written source, etc.)
