UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

THE VALIDATION OF A POTENTIAL ASSESSMENT BATTERY FOR ENGINEERING TECHNOLOGY STUDENTS

by

Helena Kriel

submitted in fulfilment of the requirements
for the degree of

**Magister Artium
(Psychology)**

in the

Faculty of Humanities

at the

University of Pretoria

Pretoria

© University of Pretoria

June 2001

UNIVERSITEIT VAN PRETORIA
2161981

Dedicated to my parents Maarten and Alta Olivier,
for relentlessly believing in me

and

to the loving memory of Mariana Bothma, for
teaching me the art of being alive

TABLE OF CONTENTS

LIST OF TABLES xi
LIST OF FIGURES xiii
SUMMARY xv
OPSOMMING xvii
ACKNOWLEDGEMENTS xix

1 INTRODUCTION 1

1.1 INTRODUCTION 1
1.2 OBJECTIVES OF THE STUDY 2
1.3 ELUCIDATION OF KEY TERMS 3
1.4 ARRANGEMENT OF CHAPTERS 4

2 THE ADMISSION OF STUDENTS TO HIGHER EDUCATION 5

2.1 INTRODUCTION 5
2.2 ADMISSION REQUIREMENTS FOR HIGHER EDUCATION 6
2.3 PARTICIPATION IN HIGHER EDUCATION 6
2.3.1 Increasing access by means of alternative/special admission methods 6
2.4 THE WHITE PAPER ON HIGHER EDUCATION 8
2.4.1 The purposes of higher education 8
2.4.2 The needs of and the challenges facing higher education 9
2.4.3 Requirements for the transformation of higher education 10
2.4.4 Vision 11
2.4.5 Principles 11
2.5 IMPLICATIONS OF LEGISLATION ON CURRENT PRACTICES IN

	HIGHER EDUCATION	13
2.5.1	Curriculum 2005	13
2.6	FINANCIAL IMPLICATIONS OF STUDENT PASS RATES	14
2.7	CONCLUSION	15
3	**SELECTION**	16
3.1	INTRODUCTION	16
3.2	DEFINING THE CONCEPT	16
3.3	PRINCIPLES UNDERLYING THE DEVELOPMENT OF A SELECTION PROCEDURE	17
3.3.1	The design cycle concept of Roe	17
3.3.1.1	Definition	17
3.3.1.2	Analysis	19
3.3.1.3	Synthesis	19
3.3.1.4	Simulation	19
3.3.1.5	Evaluation	20
3.3.1.6	Decision making	20
3.3.2	Major functions of the selection procedure	20
3.3.2.1	The information-gathering function	20
3.3.2.2	The prediction function	21
3.3.2.2.1	The sign approach	21
3.3.2.2.2	The sample approach	23
3.3.2.3	Decision-making function	25
3.3.2.4	Information supplying function	25
3.3.3	Applying the design cycle to predictive performance models	25
3.3.3.1	Steps in developing prediction performance models for selection	28
3.3.3.1.1	Defining the problem	28

3.3.3.1.2	Specifying model requirements	28
3.3.3.1.3	Specifying model content	28
3.3.3.1.4	Structure	28
3.3.3.1.5	Form	29
3.3.3.1.6	Estimating parameters	29
3.3.3.1.7	Evaluation of the model	29
3.3.4	Considerations in the design of selection procedure	29
3.4	REDEFINING "FAIRNESS" IN SELECTION	30
3.5	STRATEGIES FOR SELECTION FAIRNESS	31
3.5.1	The regression models	32
3.5.2	Equal risk model	39
3.5.3	Constant ratio model	39
3.5.4	Conditional probability model	40
3.5.5	Modified criterion/Subjective regression model	41
3.6	DECISION-MAKING FOR SELECTION	42
3.6.1	The Taylor-Russel utility model	43
3.6.2	The Naylor-Shine model	44
3.6.3	The Brogden-Cronbach-Gleser model	44
3.7	CONCLUSION	45
4	**PSYCHOMETRIC TESTING**	46
4.1	INTRODUCTION	46
4.2	THE AIM OF PSYCHOMETRIC TESTING	47
4.3	PSYCHOMETRICS AT A CROSSROAD	48
4.4	THE NATURE OF PSYCHOMETRIC TESTS	52
4.4.1	Definition	52
4.4.2	Standardisation	53
4.4.3	Objectivity	54
4.4.4	Validity	55

4.4.4.1	Contend-related validity	55
4.4.4.2	Construct-related validity	56
4.4.4.3	Criterion-related validity	56
4.4.4.3.1	Selecting the criteria	57
4.4.4.3.2	Validity coefficient	59
4.4.5	Reliability	59
4.4.6	Test bias	61
4.5	CONCLUSION	64
5	**CRITERION DEVELOPMENT**	65
5.1	INTRODUCTION	65
5.2	DEFINING THE CONCEPT	65
5.3	CRITERION PROBLEM	66
5.4	CRITERION CONTAMINATION	66
5.5	DIMENSIONALITY OF CRITERIA	66
5.5.1	Temporal dimensionality	67
5.6	ESSENTIALS OF CRITERIA DEVELOPMENT	69
5.6.1	Reliability of Performance	69
5.6.2	Reliability of job performance observations	70
5.6.3	Dimensionality of job performance	70
5.6.4	Performance and situational characteristics	71
5.7	STEPS IN THE DEVELOPMENT OF CRITERION	71
5.8	EVALUATING CRITERIA	72
5.8.1	Relevance	72
5.8.2	Sensitivity or discriminability	73
5.8.3	Practicality	73
5.9	CONCLUSION	73

6	**PREDICTORS OF ACADEMIC SUCCESS**	75
6.1	INTRODUCTION	75
6.2	SCHOLASTIC PERFORMANCE	75
6.3	LEARNING POTENTIAL	78
6.4	GENERAL COGNITIVE ABILITY AND SPECIFIC APTITUDE	80
6.5	BIOGRAPHICAL FACTORS	83
6.6	PREDICTORS OF SUCCESS IN ENGINEERING AND ENGINEERING TECHNICIAN COURSES	84
6.7	CONCLUSION	97
7	**POTENTIAL INDEX BATTERIES**	99
7.1	INTRODUCTION	99
7.2	THE NATURE OF THE POTENTIAL INDEX BATTERIES (PIB)	100
7.2.1	Description of the relevant individual indices of the V-PIB and PIB	101
7.2.1.1	Visual Potential Index Batteries	101
7.2.1.2	Potential Index Batteries	102
7.3	VALIDITY AND RELIABILITY OF PIB	103
7.4	CONCLUSION	104
8	**RESEARCH METHODOLOGY**	105
8.1	INTRODUCTION	105
8.2	RESEARCH DESIGN	106
8.3	DATA COLLECTION	107
8.3.1	Uses of psychological tests in research	109
8.4	DATA ANALYSIS	110
8.5	CONCLUSION	111

9	**THE SAMPLE**	112
9.1	INTRODUCTION	112
9.2	THE POPULATION	112
9.3	THE SAMPLE	112
9.3.1	Factors to be taken into consideration when sampling	113
9.3.2	The sample size	113
9.3.3	The sample for this study	114
9.4.	CONCLUSION	116
10	**STATISTICAL TECHNIQUES**	117
10.1	INTRODUCTION	117
10.2	DESCRIPTIVE STATISTICS	118
10.2.1	Measures of central tendency	118
10.2.1.1	The mode	118
10.2.1.2	The median	118
10.2.1.3	The mean	119
10.2.2	Measures of variability	119
10.2.2.1	Variance	119
10.2.2.2	Standard deviation	119
10.2.3	Frequency distribution	120
10.3	INFERENTIAL STATISTICS	120
10.3.1	Correlation coefficients	120
10.3.2	Multiple regression analysis	121
10.3.2.1	The standard error of estimate	123
10.4	LEVELS OF SIGNIFICANCE	123
10.5	STEPS TAKEN IN STATISTICAL ANALYSIS	123
10.6	CONCLUSION	124

11 DETERMINING THE PREDICTOR VARIABLES 125

11.1 INTRODUCTION 125
11.2 THE COMPREHENSIVE STRUCTURED INTERVIEWING FOR POTENTIAL SYSTEM 125
11.3 ACADEMIC CRITERIA 126
11.4. CONCLUSION 127

12 RESEARCH FINDINGS 128

12.1 INTRODUCTION 128
12.2 DESCRIPTIVE STATISTICS OF PREDICTOR VARIABLES 128
12.3 RELIABILITY OF PIB INDICES 137
12.4 PREDICTIVE VALIDITY OF VARIABLES 138
12.4.1 Summary of results found for Civil Engineering Technology 152
12.4.2 Summary of results found for Mechanical Engineering Technology 174
12.5 CONCLUSION 175

13 CONCLUSIONS AND RECOMMENDATIONS 176

13.1 INTRODUCTION 176
13.2 CONCLUSIONS 176
13.3 RECOMMENDATIONS 178
13.4 LIMITATIONS OF THIS STUDY 181

LIST OF REFERENCES 184

LIST OF TABLES

Table 6.1:	Quantification of Matriculation Symbols	76
Table 6.2:	Correlations indicating factors with significant relation to the academic success of students in Civil Engineering	89
Table 6.3:	Predictive validity coefficients of the selection tests used at the University of the North's Foundation Year as calculated with the final academic performance as criterion	96
Table 12.1:	Descriptive statistics of results obtained by the respondents on the PIB indices used in the study	129
Table 12.2:	Reliability coefficients as computed for indices used in the assessment of the potential of prospective Engineering Technology students	137
Table 12.3:	Result of multiple regression analysis performed on data, using a final average score for Civil Engineering Technology as criterion	139
Table 12.4:	Result of multiple regression analysis performed on data, using a final Drawing score for Civil Engineering Technology, as criterion	142
Table 12.5:	Result of multiple regression analysis performed on data, using a final Mathematics score for Civil Engineering Technology as criterion	145
Table 12.6:	Result of multiple regression analysis performed on data, using a final Construction Materials score for Civil Engineering Technology as criterion	147
Table 12.7:	Result of multiple regression analysis performed on data, using a final Applied Mechanics score for Civil Engineering Technology as criterion	151
Table 12.8:	Result of multiple regression analysis performed on data, using a final average score for Mechanical Engineering Technology as criterion	153

Table 12.9:	Result of multiple regression analysis performed on data, using a final Electro-technology score for Mechanical Engineering Technology as criterion	156
Table 12.10:	Result of multiple regression analysis performed on data, using a final Communication score for Mechanical Engineering Technology as criterion	159
Table 12.11:	Result of multiple regression analysis performed on data, using a final Drawing score for Mechanical Engineering Technology as criterion	162
Table 12.12:	Result of multiple regression analysis performed on data, using a final Manufacturing Engineering score for Mechanical Engineering Technology as criterion	164
Table 12.13:	Result of multiple regression analysis performed on data, using a final Mechanics score for Mechanical Engineering Technology as criterion	167
Table 12.14:	Result of multiple regression analysis performed on data, using a final Computer Skills score for Mechanical Engineering Technology as criterion	169
Table 12.15:	Result of multiple regression analysis performed on data, using a final Mathematics score for Mechanical Engineering Technology as criterion	172
Table 13.1:	Matrix of variables that played a role in the prediction of performance on the criterion variables	180

LIST OF FIGURES

Figure 3.1:	The design cycle model as adapted from Roe	18
Figure 3.2:	Diagnostic procedure in the case of the sign approach	22
Figure 3.3:	Diagnostic procedure in the case of the sample approach	24
Figure 3.4:	Steps in the development of predictive performance Models in accordance to the design cycle model	27
Figure 3.5:	Prediction from a single group regression line	33
Figure 3.6:	A graphic presentation of the distribution of scores in cases of positive validity and zero validity	34
Figure 3.7:	Different regression lines and coefficients	35
Figure 3.8:	Valid predictor with adverse impact	36
Figure 3.9:	Equal validity, unequal criterion means	37
Figure 3.10:	Unequal criterion means and validity only for the non-minority group	38
Figure 9.1:	Frequency distribution of the gender of the sample used in the study	115
Figure 9.2:	Frequency distribution of home languages spoken by respondents	116
Figure 12.1:	Frequency distribution of results obtained on the Creativity index of the PIB	131
Figure 12.2:	Frequency distribution of results obtained on the Reading Comprehension index of the PIB	132
Figure 12.3:	Frequency distribution of results obtained on the Mental Alertness index of the PIB	132
Figure 12.4:	Frequency distribution of results obtained on the	

	Vocabulary index of the PIB	134
Figure 12.5:	Frequency distribution of results obtained on the Numerical Ability index of the VPIB	134
Figure 12.6:	Frequency distribution of results obtained on the Composition of Wholes index of the VPIB	135
Figure 12.7:	Frequency distribution of results obtained on the Spatial Reasoning index of the VPIB	135
Figure 12.8:	Frequency distribution of results obtained on the Perception index of the VPIB	136

Summary

THE VALIDATION OF A POTENTIAL ASSESSMENT BATTERY FOR ENGINEERING TECHNOLOGY STUDENTS

by

Helena Kriel

Study leader: Prof RP de la Rey
Department: Psychology
Degree: Magister Artium (Psychology)

The selection of students for higher education has been a burning issue on the agenda of South African institutions of higher education for the past decade. Institutions for higher education are experiencing pressure from both their clients and the government to broaden access, but at the same time financial realities force these institutions to admit only those candidates with the potential to be successful in their chosen course of study.

The main aim of this study was the identification of variables which relate to academic success amongst Engineering Technology students at Technikon Pretoria, and to incorporate them into a selection battery which would be both valid and reliable.

A non-experimental, correlational design was selected, as this research technique is considered the best controlled and most accurate of all non-experimental designs. Since a quantitative technique was selected for data gathering, the necessity for a statistical method in the data analysing process was obvious.

The sample for this study consisted of a total of 732 Engineering Technology

students at Technikon Pretoria. From these, 512 were Civil Engineering Technology students and the remaining 220 were Mechanical Engineering Technology students. These subjects were the total number of students from these two academic departments, enrolled from 1997 to 1999, of whom both psychometric and academic data were available. The sample consisted of 14.75% female and 85.25% male respondents and was representative of the cultural diversity of the Technikon campus.

The competencies indicated by academic staff involved with the training of Engineering Technology students at Technikon Pretoria were hypothesised to be indicative of a potentially successful student. After the identification of these predictor variables the assessment battery to be used in this study was compiled. This was then included in a comprehensive set of data regarding each applicant, together with the required school performance. A forward stepwise multiple regression analysis was performed on the data in order to establish the predictive validity of the assessment battery.

The expansion of the traditional selection procedure to include the potential assessment phase proved valuable, as the validity of all prediction models improved with the addition of the indices from the Potential Index Batteries. The prediction models were found to be unbiased against students from the previously disadvantaged school systems and can thus be said to be culture fair.

Key terms: Selection; assessment; assessment battery; potential; ability; competency; validity; reliability; regression model.

OPSOMMING

DIE VALIDERING VAN 'N POTENSIAALBEPALINGSBATTERY VIR INGENIEURSTEGNOLOGIESTUDENTE

deur

Helena Kriel

Studieleier: Prof RP de la Rey
Departement: Sielkunde
Graad: Magister Artium (Sielkunde)

Die keuring van studente is vir die afgelope dekade 'n belangrike punt op die agenda van hoëronderwysinstellings in Suid-Afrika. Hoëronderwysinstansies ondervind druk van beide hul kliënte en die regering van die dag om toelating tot die instansies te verhoog, maar terselftertyd noop finansiële realiteite hierdie instansies om slegs studente toe te laat wat oor die potensiaal beskik om suksesvol in die kursus van hul keuse te wees.

Die hoofdoel van hierdie ondersoek was om die veranderlikes wat met die akademiese sukses van Ingenieurstegnologiestudente verband hou, te identifiseer en in 'n geldige en betroubare keuringsprogram op te neem.

Daar is gebruik gemaak van 'n nie-eksperimentele, korrelatiewe ontwerp, aangesien hierdie ontwerp beskou word as die mees akkurate van alle nie-eksperimentele ontwerpe. Daar 'n kwantitatiewe tegniek vir data-insamaling verkies is, was die belangrikheid van 'n statistiese tegniek vir die verwerking van die data voor die hand liggend.

Die steekproef vir die studie het bestaan uit 732 Ingenieurstegnologiestudente aan Technikon Pretoria. Hiervan was 512 Siviele Ingenieurstegnologiestudente en die

oorblywende 220 Meganiese Ingenieurstegnologiestudente. Hierdie proefpersone was die totale groep studente uit hierdie twee departemente, geregistreer vir die tydperk 1997 tot 1999, vir wie daar beide psigometriese data en akademiese resultate beskikbaar was. Die steekproef het bestaan uit 14.75% vroulike en 85.25% manlike respondente en was verteenwoordigend van die kulturele diversiteit van die Technikonkampus.

Die bevoegdhede wat deur akademiese personeel betrokke by die opleiding van Ingenieurstegnologiestudente aangedui is, is hipoteties gestel as aanduidend van 'n potensieel suksesvolle student. Nadat hierdie voorpellingsveranderlikes geïdentifiseer is, is die evalueringsbattery vir gebruik in hierdie studie saamgestel. Die psigometriese data is ingesluit in 'n omvattende databasis ten opsigte van elke kandidaat, tesame met die vereiste skoolprestasie. 'n Voorwaardse stapsgewyse regressie-ontleding is op die data uitgevoer ten einde die voorspellingsgeldigheid van die potensiaalbepalingsbattery vas te stel.

Die uitbreiding van die tradisionele keuringsprosedure deur die insluiting van die potensiaalbepalingsfase het waardevol geblyk te wees, aangesien die geldigheid van alle voorspellingsmodelle verhoog het met die insluiting van die indekse van die Potential Index Batteries. Die voorspellingsmodelle is bewys synde nie sydig te wees ten opsigte van studente uit voorheen benadeelde skoolstelsels nie en kan daarom as kultuurbillik beskou word.

Sleutelterme: Keuring; evaluering; evalueringsbattery; potensiaal; vermoë; bevoegdheid; geldigheid; betroubaarheid; regressiemodel.

Acknowledgments

My heartfelt gratitude to the following:

- **Prof Piet de la Rey**, my study leader, for his knowledgeable inputs and guidance.
- My husband **Coenie**, for his unfaltering support and encouragement, without which this dissertation would never have seen the light.
- My parents **Maarten and Alta Olivier**, for their lifelong interest in my academic career and their infallible belief in my abilities.
- My parents-in-law **Ryno and Heléne Kriel**, for their support.
- All the **Olivier and Kriel siblings**, for being interested.
- My grandmothers, **Pieta Coertze** and **Sannie Olivier**, for always taking pride in me.
- My colleagues at the Department of Student Counselling: **Elmarie, Elani, Francette, Ilzé, Letta, Lorika and Marlize**, for all they did to give me the opportunity to complete this study.
- My former manager and mentor, the late **Mariana Bothma**, for the initiative that lead to the undertaking of this study.
- **Ingrid Swanepoel**, for capable and meticulous revision of grammar and style.

- **The NRF for the financial support that made this study possible. The views expressed in this study are those of the author, and not necessarily that of the NRF.**

SOLE DEO GLORIA !