Chapter 12
Research findings

12.1 Introduction

The aim with the current study was to establish a potential assessment battery for the Engineering Technology courses at Technikon Pretoria that would be accurate, effective, fair and efficient. The Technikon Pretoria Potential Assessment Battery for Engineering Technology students was evaluated on the grounds of empirical research data collected in the period 1996 to 1999. The determination of the predictive validity of school performance (as indicated by symbols obtained), formed part of this study, as this still forms an integral part of the selection procedure at Technikon Pretoria.

In this chapter, the results of the study will be reported, as they relate to the objectives stated in Chapter 1. The chapter contains the descriptive statistics of the various predictive variables, the reliability of the indices used for the potential assessment and the predictive validity of the variables as determined by multiple regression analysis.

12.2 Descriptive statistics of predictor variables

Table 12.1 contains a summary of the descriptive statistics of the results obtained by the respondents on the indices of the Potential Index Batteries included in the assessment of prospective Engineering Technology students at Technikon Pretoria.

Table 12.1: Descriptive statistics of results obtained by the respondents on the PIB indices used in the study (maximum score possible indicated in brackets).

Index	Mean	Median	Standard Deviation
Creativity (100)	46.705	47.500	4.300
Reading Comprehension (100)	65.873	68.000	14.044
Mental Alertness (100)	83.139	84.000	6.919
Vocabulary (100)	78.759	86.000	17.710
Numerical Ability (10)	5.771	5.000	1.629
Composition of Wholes (10)	6.519	7.000	2.550
Spatial Reasoning (10)	5.089	5.000	1.531
Perception (10)	6.392	6.000	2.124
Mathematics (5)	1.983	2.000	1.174
Physical Science (5)	1.903	2.000	1.046

When interpreting the descriptive statistics, it is important to realise that these statistics describe the scores obtained by a preselected group. Only the scores of those students who were finally admitted to either the Civil Engineering Technology or the Mechanical Engineering Technology course were included in the analysis. It is inevitable that the distributions of scores will not be normal in all instances. The researcher took cognizance of the fact that this might influence the validity of the prediction models.

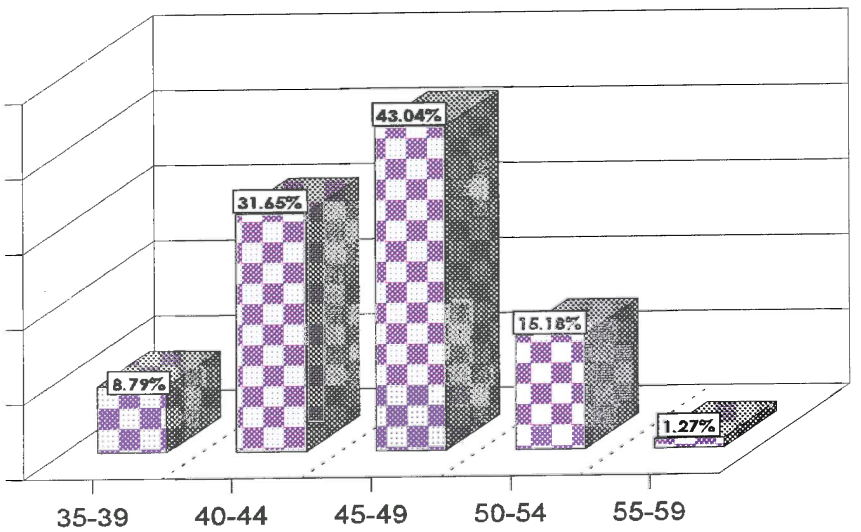
Table 11.1 indicates that in almost all of the indices used the median is higher than the mean of scores obtained (with the exception of the Numerical Ability, Spatial Reasoning and Perception indices). The majority of respondents can thus be said

to have performed better than the mean. This phenomenon could most likely be explained by the fact that most of the applicants who performed below the average on more than half of the indices were not admitted to the relevant courses and their scores are thus not represented by these statistics. There were, however, applicants who obtained low scores on one or two indices only, and who were admitted to the Engineering Technology courses. Their scores are included in this set of descriptive statistics. As these scores were sometimes extremely low, they influenced the mean calculated for that particular set of scores.

As explained in Chapter 10, the standard deviation provides information about the distance, on the average, of the scores from the mean. It can thus be deduced from the information given in Table 12.1 that a wider range of scores was obtained on the Reading Comprehension and Vocabulary indices. This could be explained by the fact that students who performed lower than average on these two indices only were not rejected, but were conditionally admitted (the condition being that they receive formal study guidance and English literacy intervention).

The frequency distribution of the results obtained by the respondents included in the sample are presented graphically in Figures 12.1 to 12.8.

Figure 12.1: Frequency distribution of results obtained on the Creativity index of the PIB.



From Figure 12.1 it can be seen that the highest frequency of results obtained by the students on the Creativity index fell into the 45-49 range (43.04%). It can furthermore be seen that the range in which the respondents scored was limited between 35 and 59. In other words, the students obtained neither extremely low scores nor extremely high scores on this index. This could also be seen from Table 12.1 as the difference between the mean and median were relatively small, as was the standard deviation of the scores obtained on this index.

Figure 12.2: Frequency distribution of results obtained on the Reading Comprehension index of the PIB.

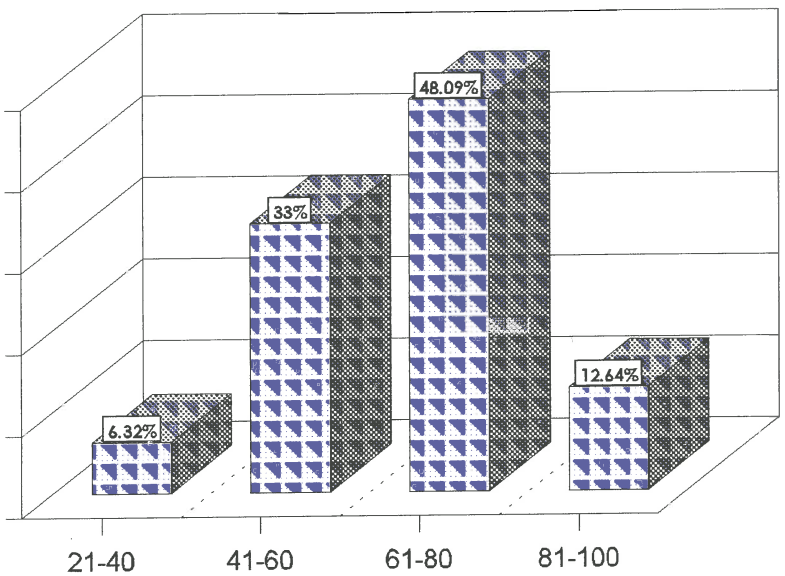


Figure 12.3: Frequency distribution of results obtained on the Mental Alertness index of the PIB.

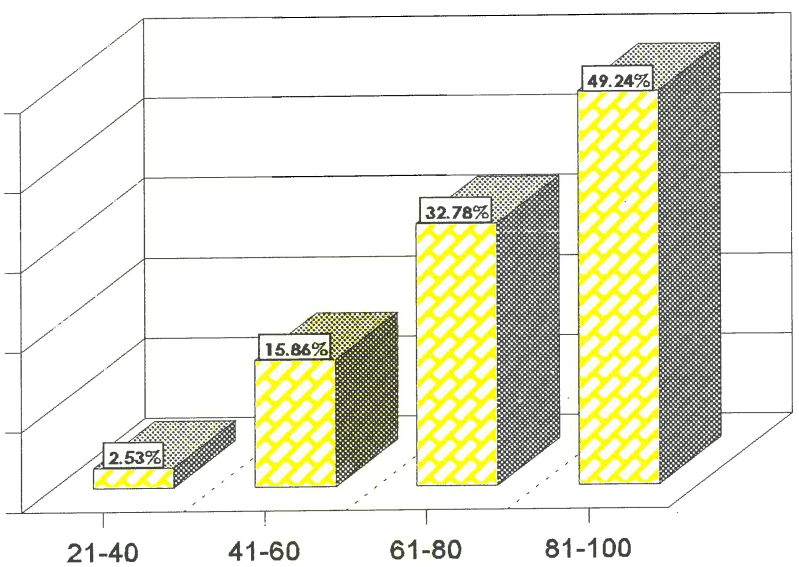


Figure 12.2 shows that the majority of respondents (48.09%) obtained results in the 61-80 range. It is also clear that a fairly large proportion of the respondents

obtained scores that were considerably lower than the mean, as 39.23% of the respondents obtained a score lower than or equal to 60 ($\bar{x}$ = 65.87). The range of results that were obtained varied between 21 and 100, which confirms the deduction made from Table 12.1 concerning the higher standard deviation. The fact that applicants were admitted to the various Engineering Technology courses despite performing much lower than average on this index can be seen clearly in this graph.

Figure 12.3 indicates the frequency distribution of the results obtained on the Mental Alertness index by the students admitted to the Engineering Technology courses. It is clear from the graph that the performance of the greatest majority of students' (49.24%) fell into the 81-100 range. Due to research done in other sectors, which indicated that this specific index has a high predictive validity for work performance, the counsellors who assessed the performance were much less lenient regarding an applicant's performance on this index. The result of this is quite clear from Figure 12.3 - the distribution indicates that very few applicants who did not perform at least average on this index were admitted to the various Engineering Technology courses.

Figure 12.4 shows that the majority of students performed better than average on the Vocabulary index of the PIB. Once again this shows that, in the assessment of the results, students who performed below average on this index were still admitted to the Engineering Technology courses. This is also confirmed by the standard deviation of 17.71 calculated for this set of data.

Figure 12.4: Frequency distribution of results obtained on the Vocabulary index of the PIB.

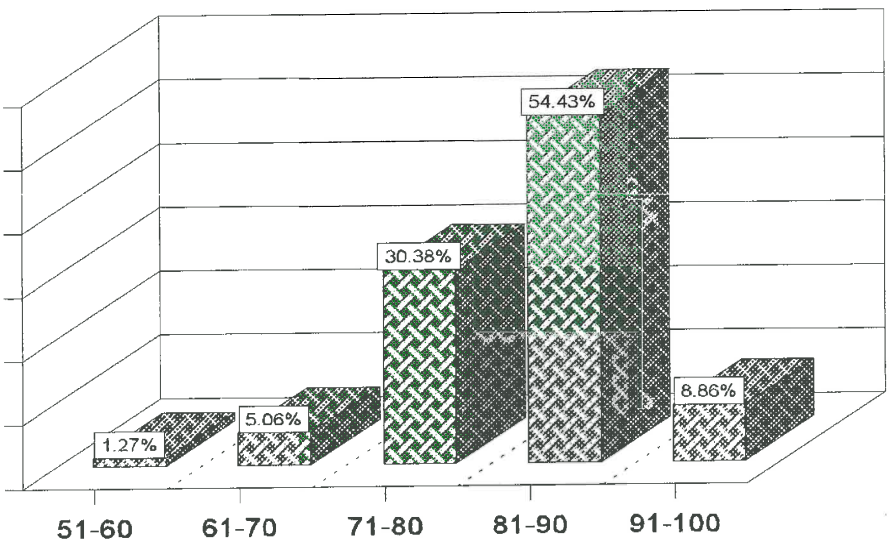


Figure 12.5: Frequency distribution of results obtained on the Numerical Ability index of the VPIB.

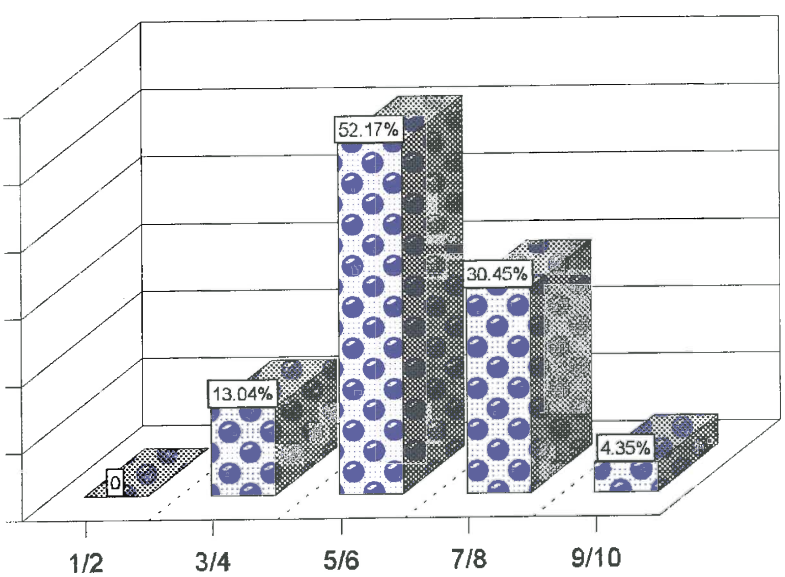


Figure 12.6: Frequency distribution of results obtained on the Composition of Wholes index of the VPIB.

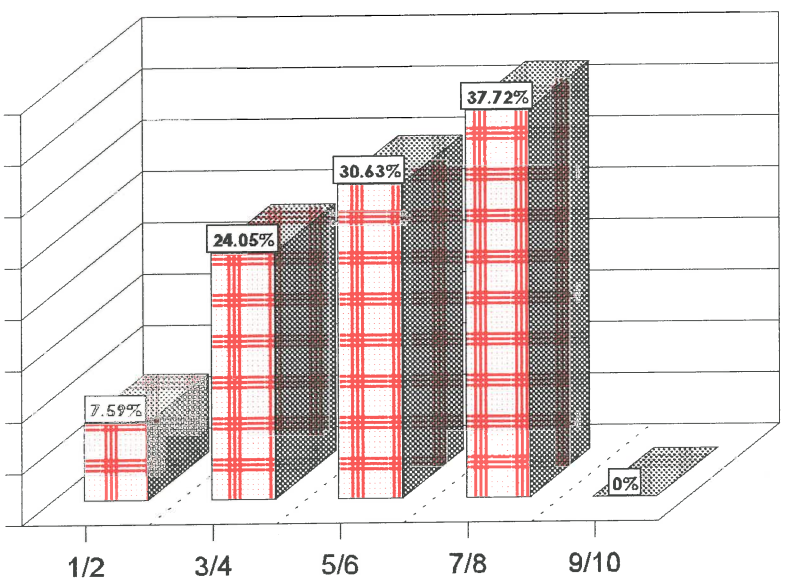


Figure 12.7: Frequency distribution of results obtained on the Spatial Reasoning index of the VPIB.

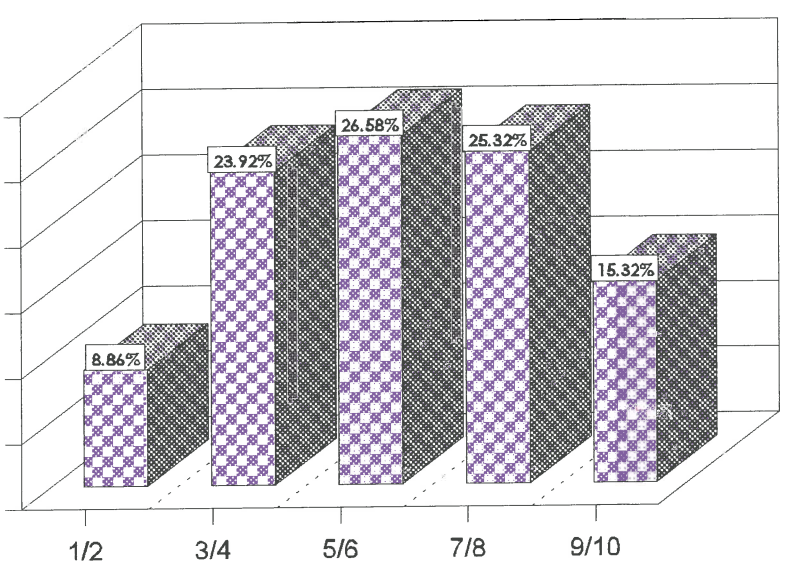
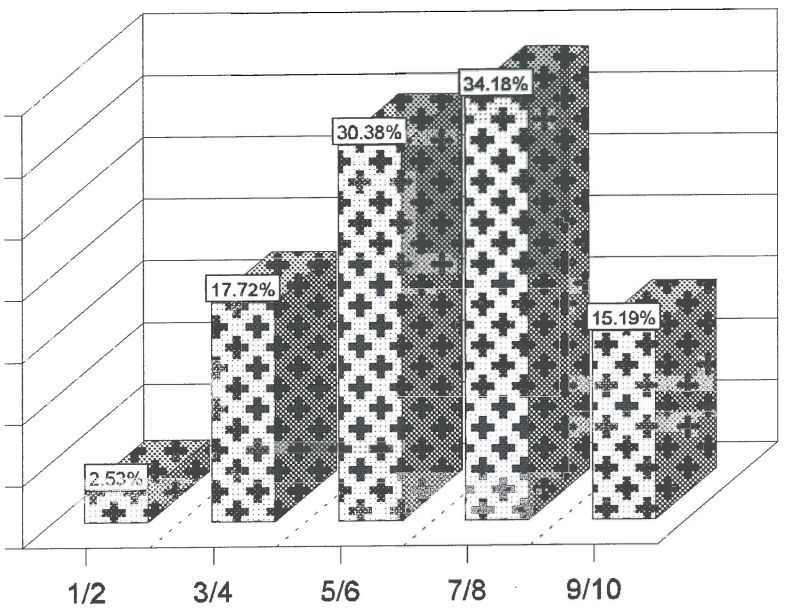


Figure 12.8: Frequency distribution of results obtained on the Perception index of the VPIB.



From Figure 12.5 it is clear that the majority of students admitted to the Engineering Technology courses obtained scores in the 5-6 range (the maximum score on this index equals 10) on the Numerical Ability index. Applicants who scored lower than 5 on this test were seldom admitted to the Engineering Technology courses, as it was felt that numerical ability should be important for Engineering Technology students. The smaller range is confirmed by the lower standard deviation calculated for this set of data, as depicted in Table 12.1.

Figure 12.6 shows that the bulk of the performance of students (68.35%) admitted to the engineering courses on the Composition of Wholes index fell into the 5-8 range. This index seemed to be fairly difficult, as none of the admitted applicants obtained a full score. Since applicants who scored low on this test were admitted in some instances, the standard deviation is higher than in the case of some of the other indices.

From Figures 12.7 and 12.8 it can be seen that applicants were admitted to the

various Engineering Technology courses even though they performed poorly on the Spatial reasoning and Perception Indices. The majority of students obtained results in the 3 - 8 range.

12.3 Reliability of PIB indices

The following situation-specific reliability coefficients were obtained for the PIB-indexes used in the assessment of the academic potential of prospective Engineering Technology students at Technikon Pretoria:

When the possible answers to an item consisted of an item range, Cronbach's coefficient Alpha was computed. Where the possible answers were dichotomous, the Kuder-Richardson formula-20 was used.

Generally, a reliability coefficient of 0.75 for cognitive indices and 0.65 for emotional/social indices is considered acceptable.

Table 12.2: Reliability coefficients as computed for indices used in the assessment of the potential of prospective Engineering Technology students.

Index	Method	Reliability coefficient
Creativity	Cronbach	**0.75**
Reading Comprehension	KR20	**0.83**
Mental Alertness	KR20	**0.87**
Vocabulary	KR20	**0.76**
Numerical Ability	KR20	**0.68**
Composition of Wholes	KR20	**0.84**

Index	Method	Reliability coefficient
Spatial Reasoning	KR20	**0.79**
Perception	KR20	**0.79**

From Table 12.2 it can be seen that the reliability of the indices of the PIB fell into an acceptable range, except for that of the Numerical Ability index, which was lower than generally expected.

12.4 Predictive validity of variables

The final academic performance of first-semester Civil and Mechanical Engineering Technology students was used as the criterion for the calculation of the predictive validity coefficients. The predicate mark (year mark) was used as the final mark for students who did not write the final examination, or were not allowed (because of poor performance) to write the final examination. Firstly, the group was split into a Civil Engineering Technology and Mechanical Engineering Technology group, as some of the subjects included in the respective training programmes differ. Thereafter, the final average score for each student was calculated and used as criterion for the multiple regression analysis performed on the data. The results for each academic subject were then used as criterion for a multiple regression analysis performed. The results of the multiple regression analysis are given in Tables 12.3 to 12.15

Table 12.3: Result of multiple regression analysis performed on data, using a final average score for Civil Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Multiple Regression Coefficient	0.319	0.432	0.537	0.594	0.604	0.614
R-Square	0.102	0.187	0.289	0.353	0.366	0.377
Standard Error of Estimate	8.986	8.566	8.028	7.670	7.610	7.558
F-Ratio	28.980	29.308	34.361	34.528	29.059	25.297
Degrees of Freedom	1,256	2,255	3,254	4,253	5,252	6,251
p-level	0.000	0.000	0.000	0.000	0.000	0.000
Constant	50.109	81.148	75.789	81.319	74.972	88.356
Mathematics	2.92	2.95	3.614	4.096	4.005	3.912
Creativity		-0.695	-0.773	-0.781	-0.735	-0.659
Composition of Wholes			1.146	1.423	1.326	1.483
Perception				-1.285	-1.303	-1.414
Numerical Ability					0.054	0.066
Mental Alertness						0.219

For the criterion variable ***Final Average Score*** for the Civil Engineering Technology course, R=0.614, and 37.7% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The Grade 12 symbol obtained for **Mathematics** (β=0.425) made the greatest contribution to the prediction of the final average score obtained by the students. However, adding the performance of the students on the **Composition of Wholes** index (β=0.410) of the Visual Potential Index Batteries to the prediction, the predictive validity of the assessment battery for the final average score obtained by Civil Engineering Technology students was significantly increased.

Students who scored low on Grade 12 Mathematics as well as on the Composition of Wholes index could thus have been expected to have a low final average score. The opposite would then also be true: a student who scored high on Grade 12 Mathematics as well as on the Composition of Wholes index could be expected to have a high final average score.

An inverted relation was found to exist between the criterion and the performance on the predictor variables **Creativity** and **Perception**. It thus seems as if those students who perceived themselves as less creative had a higher chance of achieving a high final average score than those who perceived themselves as innovative and not sticking to the tried ways. Furthermore, those students who were less able to perceive detail as well as wholes in their specific and logical context seemed to have performed better on the criterion variable Final Average Score.

The F Ratio in step 6 is statistically significant on the 0.1% level, thus indicating a significant relation between the actual and predicted scores on the criterion variable using the model incorporated in Table 12.3.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.49, and 24.5% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents R = 0.46, and 21.6% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

For the total group, the standard error of estimate = 7.558, which indicates that the prediction of performance is less accurate than expected. It is more accurate, however, than when only Mathematics and Physical Science symbols are used

(R=0.033; Standard error of estimate = 9.191). The standard error of estimate was possibly influenced by the fact that the Grade 12 symbols were used for the performance on Mathematics and Physical Science. A matric symbol only indicates a range of performance and the variance of performance within that range is disregarded.

The standard error of estimate varies if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 7.79 and for the Black group the standard error of estimate = 9.12. The percentage of Black students wrongly admitted as well as wrongly rejected, is 1.33% higher than the respective percentages for the White group. This could possibly be ascribed to the issue raised during the discussion of the literature review regarding the unreliability of school symbols obtained in former DET schools.

The question does arise whether it is worthwhile to include the final two steps in the prediction model. Two arguments influence this debate: (a) time and money are involved in the test administration process, which might be less if the battery were shortened; and (b) the state subsidy received by Technikon Pretoria is determined by the throughput rate of students. If the state subsidy should be increased to such an extent that the time and money spent, are justified by the 0.5% fewer applicants that will be wrongly accepted as well as wrongly rejected, , the full six steps should be included in the prediction model. If not, the final two steps should be omitted. In this instance, it will be acceptable to suffice with a four-step prediction model, where **$\hat{y}$= 81.319 + 4.096 (Mathematics) - 0.781 (Creativity) + 1.423 (Composition of Wholes) - 1.285 (Perception)**

Table 12.4: Result of multiple regression analysis performed on data, using a final Drawing score for Civil Engineering Technology, as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5
Multiple Regression Coefficient	0.452	0.589	0.634	0.689	0.693
R-Square	0.204	0.347	0.401	0.475	0.481
Standard Error of Estimate	11.003	10.018	9.633	9.061	9.058
F-Ratio	28.012	28.636	23.920	24.005	19.434
Degrees of Freedom	1,163	2,162	3,161	4,160	5,159
p-level	0.000	0.000	0.000	0.000	0.000
Constant	37.419	92.092	98.961	100.508	95.743
Composition of Wholes	2.194	2.206	2.451	2.698	2.624
Creativity		-1.175	-1.157	-1.302	-1.276
Perception			1.473	1.801	1.813
Mathematics				3.401	3.319
Numerical Ability					0.053

Table 12.4 shows that for the criterion variable ***Drawing*** for Civil Engineering Technology, R= 0.693, and 48.1% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The most significant contribution to the prediction of performance on the criterion variable Drawing was the performance of the students on the **Composition of Wholes** index (β= 0.541)of the Visual Potential Index Batteries. It can therefore be deduced that the capacity for concrete reasoning as regards forms and figures and their logical place within a single structure plays an important role in the potential to master the more complicated field of Technical Drawing for Engineers.

By adding the students' performance on the predictor variable **Perception** (β=0.290), the predictive validity of the assessment battery is increased significantly. Those students who were able to perceive detail as well as wholes in their specific, logical context, seem to have a higher probability of being successful in Technical Drawing for Engineers.

The students' Grade 12 **Mathematics** performance further contributed significantly to the predictive validity of the assessment battery for the subject Technical Drawing for Engineers.

An inverted relation was found to exist between the criterion variable and the performance on the predictor variable **Creativity**. Again it seems as if those students who perceived themselves as being less creative had a better chance of achieving a high Drawing score than those who perceived themselves as innovative and not sticking to the tried ways.

It can therefore be expected that a student who scored high on the Composition of Wholes and Perception indices as well as on Grade 12 Mathematics would have a high Technical Drawing score. Furthermore a student who perceives himself or herself as less creative is more likely to obtain a high score on Technical Drawing.

The F Ratio in step 5 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.64, and 41% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents

R = 0.56, and 31.5% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 9.154. As in the case of the previous criterion variable, the standard error of estimate may be influenced by the fact that only symbols were available as an indication of the Mathematics performance in Grade 12, and the students' actual performances on this predictor variable could in fact, be anywhere within a particular range.

The standard error of estimate alters if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 8.13 and for the Black group the standard error of estimate = 13.80. The percentage of Black students wrongly admitted as well as wrongly rejected is 5.67% higher than that of the White group. Implemented in its current form, the prediction model might thus be biased for the criterion variable Drawing for Civil Engineering Technology and warrants further investigation.

The inclusion of the final step of the prediction model seems unnecessary, as it will not influence the accuracy of the model significantly. The final model is:

$\hat{y}$ = 100.508 + 2.698 (Composition of Wholes) -1.302 (Creativity) + 1.801 (Perception) + 3.401 (Mathematics)

From Table 12.5 it is clear that for the criterion variable ***Mathematics***, R = 0.807, and 65.1% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The Grade 12 symbol obtained for **Mathematics** (β= 0.652) made the greatest contribution to the prediction of the final Mathematics score obtained by the students. However, by adding the performance of the students on the

Composition of Wholes index (β= 0.572) of the Visual Potential Index Batteries to the prediction, the predictive validity of the assessment battery for the Mathematics score obtained by Civil Engineering Technology students was significantly increased. The addition of the performance of the students on the **Mental Alertness** index further enhanced the predictive validity of the assessment battery for the criterion variable Mathematics.

Table 12.5: Result of multiple regression analysis performed on data, using a final Mathematics score for Civil Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Multiple Regression Coefficient	0.475	0.550	0.648	0.744	0.761	0.784	0.807
R-Square	0.225	0.303	0.421	0.554	0.579	0.615	0.651
Standard Error of Estimate	10.958	10.424	9.528	8.386	8.169	7.831	7.477
F-Ratio	51.732	38.445	42.628	54.316	47.891	46.142	45.926
Degrees of Freedom	1,178	2,177	3,176	4,175	5,174	6,173	7,172
p-level	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	41.618	52.033	44.834	113.175	108.639	122.422	133.154
Mathematics	5.517	6.107	7.046	7.183	6.790	6.951	7.674
Perception		-1.768	-2.509	-2.920	-2.844	-2.912	-2.594
Composition of Wholes			1.540	2.213	2.328	02.357	2.464
Mental Alertness				0.827	0.635	0.410	0.401
Reading Comprehension					-0.175	-0.242	-0.209
Creativity						-0.605	-0.811
Physical Science							-4.081

The relation between the criterion variable Mathematics and the matric symbol for **Physical Science** is reversed, as are the relations between the criterion variable and the performance on the predictor variables **Perception**, **Reading Comprehension** and **Creativity**.

It can be expected that a student who scored high on Grade 12 Mathematics, the Composition of Wholes and Mental Alertness indices will have a high Mathematic score.

It furthermore seems as if low performances on Perception, Creativity, Reading Comprehension and Grade 12 Physical Science can be associated with a high score in Mathematics for Civil Engineering Technology students.

The F Ratio in step 7 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.78, and 57.1% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents R = 0.67, and 47.4% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 7.477, which is again higher than would have been ideal, but still much lower than the standard error of estimate of 13.057 found for only the predictor variables Grade 12 symbol in Mathematics and Physical Science. Once again the issue of the use of symbols representing a range of possible performances already mentioned could explain the high standard error of estimate.

The standard error of estimate varies if the prediction model is applied to the main cultural groups separately. For the White group the standard error of estimate = 8.07 and for the Black group the standard error of estimate = 9.21. The

percentage of Black students wrongly admitted as well as wrongly rejected is 1.14% higher than that of the White group. This could possibly again be ascribed to the unreliability of school symbols obtained in former DET schools.

As the addition of the final step increases by almost 4% the percentage of variance in the performance on the criterion variable explained, the seventh step is included in the prediction model.

The final model is: **$\hat{y}$= 133.154 + 7.675 (Mathematics) - 2.595 (Perception) + 2.464 (Composition of Wholes) + 0.401 (Mental Alertness) - 0.209 (Reading Comprehension) - 0.811 (Creativity) - 4.081 (Physical Science)**

Table 12.6: Result of multiple regression analysis performed on data, using a final Construction Materials score for Civil Engineering Technology as criterion.

	Step 1	Step 2	Step 3
Multiple Regression Coefficient	0.417	0.480	0.510
R-Square	0.174	0.230	0.260
Standard Error of Estimate	7.784	7.538	7.419
F-Ratio	32.035	22.614	17.536
Degrees of Freedom	1,152	2,151	3,150
p-level	0.000	0.000	0.000
Constant	44.969	68.267	52.978
Numerical Ability	0.224	0.211	0.186
Creativity		-0.488	-0.611
Mental Alertness			0.264

Table 12.6 indicates that for the criterion variable ***Construction Materials*** for Civil Engineering Technology, R = 0.510, and 26.0% of the variance in the criterion

variable can be explained by the variance in the predictor variables included in the prediction model.

The predictor variable **Numerical Ability** (β = 0.348) made the greatest contribution to the prediction of a final mark for the subject Construction Materials for Civil Engineering Technology. Those students who displayed the mainly verbal potential to calculate were thus those who had the greater possibility of being successful in the Construction Materials subject.

Performance on the **Mental Alertness** index (β = 0.187) made a slight contribution to the predictive validity of the assessment battery for the criterion variable Construction Materials.

An inverted relation between the criterion variable and the predictor variable **Creativity** was recorded.

A high score on the Numerical Ability and Mental Alertness indices is thus associated with a high score on the criterion variable Construction Materials, as is a low score on the Creativity index.

The F Ratio in step 3 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.50, and 25% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents, R = 0.54, and 31.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both

groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 7.419. As reported earlier in this chapter, a slightly lower than acceptable reliability coefficient was found for the Numerical Ability index. As reliability is known to influence validity, the error of estimate could partially be contributed to the limited reliability of the predictor variable.

The standard error of estimate varies if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 9.20 and for the Black group the standard error of estimate = 8.06. The percentage of White students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 1.14% higher than that of the Black group. It is noticeable that the school grades did not play a role in the prediction of the performance on this criterion variable, and it is the only model for Civil Engineering Technology where the standard error of estimate for the Black group is lower than for the White group. This might again confirm the deduction made through the literature study regarding the unreliability of school marks from former DET schools.

As the addition of the final step increases by 3% the percentage of variance in the performance on the criterion variable explained, the third step is included in the prediction model.

The final prediction model is: $\hat{y}$ **= 52.978 + 0.186 (Numerical Ability) -0.611 (Creativity) + 0.264 (Mental Alertness)**

Table 12.7 shows that for the criterion variable ***Applied Mechanics*** for Civil Engineering Technology, R = 0.536, and 26.0% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The Grade 12 symbols obtained for **Mathematics** (β= 0.303) and **Physical Science** (β= 0.285) made the greatest contribution to the prediction of the final Mechanics score obtained by the students.

The addition of the performances of the students on the **Composition of Wholes** (β= 0.247) and **Spatial Reasoning** (β= 0.270) indices of the Visual Potential Index Batteries to the prediction significantly increased the predictive validity of the assessment battery for the final Mechanics score obtained by Civil Engineering Technology students.

Inverted relations were found to exist between the performance on the criterion variable and the performances on the **Perception** and **Creativity** indices.

Students who scored low on Grade 12 Mathematics and Science as well as on the Composition of Whole and Spatial Reasoning indices could thus have been expected to have a low final Applied Mechanics score. High scores on the Perception and Creativity indices can also be associated with a high final Applied Mechanics score.

The F Ratio in step 6 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.54, and 29% of the variance in the criterion variable can be explained by the variance in the

Table 12.7: Result of multiple regression analysis performed on data, using a final Applied Mechanics score for Civil Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Multiple Regression Coefficient	0.298	0.390	0.439	0.475	0.511	0.536
R-Square	0.089	0.152	0.193	0.225	0.261	0.287
Standard Error of Estimate	15.384	14.891	14.583	14.336	14.052	13.848
F-Ratio	14.161	12.933	11.375	10.320	9.953	9.406
Degrees of Freedom	1,145	2,144	3,143	4,142	5,141	6,140
p-level	0.000	0.000	0.000	0.000	0.000	0.000
Constant	43.415	57.234	52.751	46.273	78.324	82.425
Mathematics	4.450	4.504	4.461	5.472	4.628	4.860
Spatial Reasoning		0.918	0.853	0.879	0.713	0.723
Creativity			-2.117	-2.716	-2.867	-2.791
Physical Science				1.498	1.298	1.545
Composition of Wholes					3.547	4.946
Perception						-1.600

predictor variables included in the prediction model. For the Black respondents R = 0.40, and 16.3% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 13.848. Even though the standard error of estimate for this variable is higher than is acceptable, it is still lower than that of only the Grade 12 symbol in Mathematics and Physical Science, where the standard error of estimate = 15.613.

The standard error of estimate alters if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 11.03 and for the Black group the standard error of estimate = 13.7. The percentage of Black students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 2.67% higher than for the White group. As mainly the Grade 12 symbols for Mathematics and Physical Science contributed to the validity of the prediction model, the question raised during the literature study regarding the reliability of the results from former DET schools is raised again.

The inclusion of the final step increases the percentage of variance in the criterion variable with 2.5%, which is considered significant enough to make it worthwhile.

The final model is: **$\hat{y}$= 82.425 + 4.860 (Mathematics) + 0.723 (Spatial Reasoning) - 2.791 (Creativity) + 1.545 (Physical Science) + 4.946 (Composition of Wholes) - 1.600 (Perception)**

12.4.1 Summary of results found for Civil Engineering Technology

The results yielded by the multiple regression analysis performed on the data for Civil Engineering Technology indicate that specific predictor variables played a role in the prediction of the academic performance of students in more than one subject.

The Grade 12 Mathematics symbol consistently made the greatest contribution to the prediction of success in the Civil Engineering Technology programme. This finding corresponds with the general finding reported in Chapter 6, namely that school performance remains a good predictor of higher education academic performance. The Grade 12 Physical Science symbol does not perform as well

as a valid predictor for success in the Civil Engineering Technology programme.

The addition of the performance on the Composition of Wholes index seems to enhance the predictive validity of the assessment battery for Civil Engineering Technology in almost all subjects.

Table 12.8: Result of multiple regression analysis performed on data, using a final average score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Multiple Regression Coefficient	0.224	0.301	0.333	0.360	0.404	0.437	0.457
R-Square	0.050	0.090	0.111	0.130	0.163	0.191	0.209
Standard Error of Estimate	6.311	6.187	6.128	6.074	5.968	5.878	5.824
F-Ratio	14.480	13.567	11.308	10.111	10.523	10.592	10.102
Degrees of Freedom	1,274	2,273	3,272	4,271	5,270	6,269	7,268
p-level	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	58.530	60.208	53.827	50.770	54.741	57.284	59.351
Creativity	-3.035	-5.423	-5.511	-5.691	-5.955	-6.125	-4.695
Composition of Wholes		1.291	1.243	0.942	0.985	1.052	0.803
Mathematics			0.138	0.134	0.117	0.117	0.105
Mental Alertness				0.837	1.547	2.268	2.676
Reading Comprehension					-1.407	-1.438	-1.300
Vocabulary						-1.943	-2.383
Spatial Reasoning							-2.163

For the criterion variable ***Final Average Score*** for the Mechanical Engineering Technology course, R=0.457, and 20.9% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The predictor variable **Mental Alertness** (β= 0.499) made the greatest contribution to the prediction of a final average score for Mechanical Engineering Technology. Those students who displayed the mainly verbal potential to classify objects correctly were thus those who had a greater possibility of obtaining a higher final average score. This test is also associated with the general mental ability or G-factor of intelligence (Schaap: 1997:70) and it could thus be said that general mental ability was the most significant predictor for the criterion variable final average score for Mechanical Engineering Technology in this study.

The addition of the performance of the students on the **Composition of Wholes** index (β= 0.166) of the Visual Potential Index Batteries to the prediction significantly increased the predictive validity of the assessment battery for the final average score obtained by the Mechanical Engineering Technology students.

A significant inverted relation was found to exist between the criterion and the performance on the predictor variable **Creativity**. It thus seems as if those students who perceived themselves as being less creative had a higher probability of achieving a high final average score than those who perceived themselves as innovative and not sticking to the tried ways.

Further significant inverted relations were also found between the criterion variable and the **Reading Comprehension** and **Vocabulary** indices of the PIB.

A student who achieved a high score on Mental Alertness and Composition of Wholes and low scores on Creativity, Reading Comprehension and Vocabulary had a good chance of obtaining a high final average score for Mechanical Engineering Technology.

The F Ratio in step 7 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the

criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.45, and 20.3% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents R = 0.51, and 30.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 5.82 which indicates that the predicted performance differs 5.82% on average from the observed performance. Using only these predictors may thus lead to a proportion of candidates admitted wrongly and the same proportion rejected wrongly.

The standard error of estimate varies if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 5.86 and for the Black group the standard error of estimate = 4.10. The percentage of White students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 1.76% higher than that of the Black group.

The final step in this prediction model seems redundant, as it does not make a significant contribution to the validity of the model.

The final prediction model is: **$\hat{y}$= 59.351 - 4.695 (Creativity) + 0.803 (Composition of Wholes) + 0.105 (Mathematics) + 2.676 (Mental Alertness) - 1.300 (Reading Comprehension) - 2.383 (Vocabulary)**

Table 12.9 indicates that for the criterion variable ***Electro-Technology*** for

Mechanical Engineering Technology, R = 0.559, and 31.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The predictor variable **Numerical Ability** made the greatest contribution to the prediction of a final mark for the subject Electro-technology for Mechanical Engineering Technology. Those students who displayed the mainly verbal potential to calculate were thus those who had the greater possibility of being successful in the subject Electro-Technology.

Table 12.9: Result of multiple regression analysis performed on data, using a final Electro-technology score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Multiple Regression Coefficient	0.260	0.357	0.429	0.467	0.493	0.542	0.559
R-Square	0.069	0.127	0.184	0.218	0.243	0.293	0.312
Standard Error of Estimate	12.013	11.654	11.286	11.071	10.915	10.563	10.441
F-Ratio	20.323	19.890	20.488	18.886	17.301	18.613	17.370
Degrees of Freedom	1,274	2,273	3,272	4,271	5,270	6,269	7,268
p-level	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	56.979	69.344	67.510	49.375	57.657	61.885	63.946
Numerical Ability	4.434	4.940	5.570	5.582	6.089	5.101	6.721
Reading Comprehension		-2.899	-5.025	-4.698	-4.955	-4.901	-5.504
Mental Alertness			3.070	3.127	3.888	2.920	2.704
Mathematics				0.283	0.315	0.273	0.308
Creativity					-4.469	-9.021	-12.380
Composition of Wholes						3.040	3.345
Perception							4.924

Performance on the **Composition of Whole** index (β= 0.360) made a significant contribution to the predictive validity of the assessment battery for the criterion variable Electro-Technology. The predictive validity of the assessment battery for this criterion variable was even further enhanced by adding the performance of the students on the **Mental Alertness** index (β= 0.262) of the PIB, as well as by the addition of the Grade 12 **Mathematics** symbol (β= 0.230).

There is a significant negative relation between the criterion variable and the performance on the predictor variables **Reading Comprehension** and **Creativity.**

A student who scored high on the Numerical Ability, Composition of Wholes as well as Mental Alertness indices and who obtained a high Grade 12 Mathematics symbol, and who scored low on the Reading Comprehension and Creativity indices can thus be expected to have a high Electro-Technology score.

The F Ratio in step 7 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.56, and 33.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents R = 0.51, and 29.6% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 10.441 which indicates that the predicted performance differs 10.44% on average from the observed performance. This implies a high percentage of applicants being rejected wrongly as well as the

same percentage being admitted wrongly if only these predictors are used. It still is lower, however, than it would have been if only Grade 12 symbols for Mathematics and Physical Science had been used (standard error of estimate = 12.18). The standard error of estimate was possibly influenced by the fact that the Grade 12 symbols were used for the performance on Mathematics and Physical Science. A matric symbol only indicates a range of performance and the variance of performance within that range is disregarded.

The standard error of estimate varies if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 9.6 and for the Black group the standard error of estimate = 10.7. The percentage of Black students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 1.10% higher than that of the White group.

It is not worthwhile to include the final step of the prediction model, as it does not contribute significantly to the validity of the model.

The final model is: **$\hat{y}$= 63.946 + 6.721 (Numerical Ability) - 5.504 (Reading Comprehension) +2.704 (Mental Alertness) + 0.308 (Mathematics) -12.380 (Creativity) + 3.345 (Composition of Wholes)**

For the criterion variable ***Communication*** for Mechanical Engineering Technology R=0.600, and 36.0% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

Table 12.10: Result of multiple regression analysis performed on data, using a final Communication score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Multiple Regression Coefficient	0.366	0.451	0.541	0.561	0.583	0.600
R-Square	0.134	0.203	0.292	0.314	0.340	0.360
Standard Error of Estimate	7.533	7.238	6.834	6.739	6.623	6.533
F-Ratio	42.310	34.782	37.451	31.065	27.838	25.247
Degrees of Freedom	1,274	2,273	3,272	4,271	5,270	6,269
p-level	0.000	0.000	0.000	0.000	0.000	0.000
Constant	53.752	61.931	59.218	54.743	50.859	44.940
Composition of Wholes	2.210	2.587	1.809	2.167	2.324	1.597
Spatial Reasoning		-4.125	-5.911	-7.114	-7.725	-9.579
Mental Alertness			2.384	2.269	1.578	1.566
Reading Comprehension				1.889	2.471	3.076
Creativity					1.601	1.936
Numerical Ability						3.902

The predictor variable **Reading Comprehension** (β= 0.380) made the greatest contribution to the prediction of a final mark for the subject Communication for Mechanical Engineering Technology. Those students who displayed the competency to read and understand clearly what the reading matter conveyed, had a greater probability of being successful in the subject Communication than those who showed limited reading comprehension ability.

The addition of the performance of the students on the **Mental Alertness** index (β= 0.334) of the Potential Index Batteries to the prediction model significantly

increased the predictive validity of the assessment battery for the final Communication score obtained by the Mechanical Engineering Technology students.

The performance of the students on the **Creativity** (β= 0.250) and **Composition of Wholes** (β= 0.264) indices enhanced even further the predictive validity of the assessment battery for the criterion variable Communication for Mechanical Engineering Technology.

A significant reversed correlation was found between the criterion variable and the predictor variable **Spatial Reasoning**.

A high score on the criterion variable Communication for Mechanical Engineering Technology is associated with high scores on the Reading Comprehension, Mental Alertness, Creativity and Composition of Wholes indices and low scores on the Spatial Reasoning index.

The F Ratio in step 6 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.58, and 33.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents R = 0.62, and 37.9% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 6.533, which means that 6.5% of the applicants

would be respectively admitted or rejected wrongly if only these predictors were to be used.

The standard error of estimate varies if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 6.47 and for the Black group the standard error of estimate = 5.09. The percentage of White students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 1.38% higher than that of the Black group.

As the addition of the final step increases the percentage of variance in the performance on the criterion variable explained with almost 2%, the sixth step is included in the prediction model.

The model is: $\hat{y}$= **44.940 + 1.598 (Composition of Wholes) - 9.579 (Spatial Reasoning) + 1.566 (Mental Alertness) + 3.076 (Reading Comprehension) + 1.936 (Creativity) + 3.902 (Numerical Ability)**

Table 12.11 shows that for the criterion variable ***Drawing*** for Mechanical Engineering Technology, R = 0.728, and 53.0% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The performance of students on the **Spatial Reasoning** index (β= 0.790) of the Visual Potential Index Batteries made the greatest contribution to the prediction of the final Drawing score obtained by the Mechanical Engineering Technology students. However, by adding the performance of the students on the **Numerical Ability** index (β= 0.581) of the Visual Potential Index Batteries to the prediction, the predictive validity of the assessment battery for the Drawing score obtained by Mechanical Engineering Technology students was significantly increased.

Table 12.11: Result of multiple regression analysis performed on data, using a final Drawing score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7
Multiple Regression Coefficient	0.352	0.430	0.502	0.621	0.715	0.720	0.728
R-Square	0.124	0.185	0.252	0.386	0.511	0.518	0.530
Standard Error of Estimate	11.232	10.857	10.418	9.458	8.455	8.409	8.322
F-Ratio	38.855	30.930	30.555	42.558	56.437	48.191	43.127
Degrees of Freedom	1,274	2,273	3,272	4,271	5,270	6,269	7,268
p-level	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	63.960	54.790	38.184	40.509	18.625	21.419	25.103
Composition of Wholes	3.158	3.677	3.158	2.049	4.755	4.598	4.987
Reading Comprehension		-2.907	-3.135	-4.686	-5.900	-6.226	-5.491
Numerical Ability			4.352	7.904	10.133	9.994	9.457
Spatial Reasoning				10.179	17.057	17.161	17.823
Creativity					-14.443	-14.534	-14.565
Vocabulary						-1.558	-2.988
Mental Alertness							1.844

The addition of the performance of the students on the **Composition of Wholes** index (β= 0.560) further enhanced the predictive validity of the assessment battery for the criterion variable Drawing.

Significant inverted relations were found between the performance on the criterion variable and the performances on the **Reading Comprehension** and **Creativity** indices.

A student who scored high on the Spatial Reasoning, Numerical Ability and Composition of Wholes indices, and who scored low on the Reading

Comprehension and Creativity indices, can thus be expected to have a high Drawing score.

The F Ratio in step 7 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.73, and 52.9% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents, R = 0.62, and 51.8% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 8.322 if the model is applied to the total group. The standard error of estimate alters marginally if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 8.018 and for the Black group the standard error of estimate = 8.410. The percentage of Black students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 0.39% higher than that of the White group.

The final step in this prediction model seems redundant, as it does not make a significant contribution to the validity of the model.

The final prediction model is: **$\hat{y}$= 21.419 + 4.598 (Composition of Wholes) - 6.226 (Reading Comprehension) + 9.994 (Numerical Ability) + 17.161 (Perception) - 14.534 (Creativity) - 1.558 (Vocabulary)**

Table 12.12: Result of multiple regression analysis performed on data, using a final Manufacturing Engineering score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4
Multiple Regression Coefficient	0.646	0.780	0.805	0.808
R-Square	0.417	0.610	0.648	0.653
Standard Error of Estimate	6.291	5.156	4.910	4.885
F-Ratio	152.974	166.604	130.149	99.392
Degrees of Freedom	1,214	2,213	3,212	4,211
p-level	0.000	0.000	0.000	0.000
Constant	74.796	94.935	93.622	90.994
Spatial Reasoning	8.964	9.784	10.117	10.210
Creativity		-7.714	-11.110	-10.995
Numerical Ability			3.084	2.964
Reading Comprehension				0.781

For the criterion variable ***Manufacturing Engineering*** for Mechanical Engineering Technology R=0.808 and 65.3% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The predictor variable **Spatial Reasoning** (β= 0.740) made the greatest contribution to the prediction of a final mark for the subject Manufacturing Engineering for Mechanical Engineering Technology. Those students who displayed the competency to perceive, analyse and synthesise, as well as the ability to select and categorised were thus the students with the highest probability of being successful in the subject Manufacturing Engineering.

The addition of the performance of the students on the **Numerical Ability** index (β= 0.264) of the Visual Potential Index Batteries to the prediction model

significantly increased the predictive validity of the assessment battery for the final Manufacturing Engineering score obtained by the mechanical engineering technology students.

A significant negative relation was found to exist between the criterion variable and the performance on the **Creativity** index.

A high score on the criterion variable Manufacturing Engineering for Mechanical Engineering Technology is associated with high scores on the Spatial Reasoning and Numerical Ability indices and low scores on the Creativity index.

The F Ratio in step 4 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.82, and 67.5% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents R = 0.77, and 59.6% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 4.89 if the prediction model is applied to the total group. The standard error of estimate alters noticeably if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 4.77 and for the Black group the standard error of estimate = 6.12. The percentage of Black students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 1.35% higher than that of the White group.

The final step in this prediction model seems to be redundant, as it does not make a significant contribution to the validity of the model.

The final model is: $\hat{y}$= **90.994 + 10.210 (Spatial Reasoning) - 10.995 (Creativity) + 2.964 (Numerical Ability)**

Table 12.13 indicates that for the criterion variable ***Mechanics*** for Mechanical Engineering Technology, R = 0.451, and 20.3% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The performance of students on the **Mental Alertness** index (β= 0.320) of the Potential Index Batteries made the greatest contribution to the prediction of the final Mechanics score obtained by the Mechanical Engineering Technology students. However, by adding the Grade 12 **Mathematics** symbol (β= 0.313) to the prediction model, the predictive validity of the assessment battery for the Mechanical score obtained by Mechanical Engineering Technology students was significantly increased.

A significant inverted relation was found to exist between the criterion variable and the performance on the **Creativity** index.

A student who scored high on the Mental Alertness index as well as on Grade 12 Mathematics and who scored low on the Creativity index can thus be expected to have a high Mechanics score.

Table 12.13: Result of multiple regression analysis performed on data, using a final Mechanics score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5
Multiple Regression Coefficient	0.292	0.412	0.421	0.436	0.451
R-Square	0.085	0.170	0.178	0.190	0.203
Standard Error of Estimate	15.771	15.053	15.010	14.922	14.827
F-Ratio	25.610	27.941	19.585	15.915	13.796
Degrees of Freedom	1,274	2,273	3,272	4,271	5,270
p-level	0.000	0.000	0.000	0.000	0.000
Constant	2.073	22.547	27.356	25.675	31.979
Mathematics	0.588	0.642	0.626	0.656	0.630
Mental Alertness		10.067	9.454	10.668	10.985
Vocabulary			-2.074	-4.060	-4.135
Creativity				-2.056	-3.245
Reading Comprehension					-2.265

The F Ratio in step 5 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.49, and 23.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents, R = 0.43, and 19.3% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both

groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 14.827 if the prediction model is applied to the total group, which indicates that the predicted performance differs 14.83% on average from the observed performance. This implies a high percentage of applicants being rejected wrongly as well as the same percentage being admitted wrongly if only these predictors are used. It still is lower, however, than it would have been if only Grade 12 symbols for Mathematics and Physical Science were used (standard error of estimate = 15.771). Again, the issue of the use of symbols representing a range of possible performances already mentioned could explain the high error of estimate.

The standard error of estimate alters noticeably if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 13.58 and for the Black group the standard error of estimate = 16.92. The percentage of Black students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 3.34% higher than for the White group. As the Grade 12 symbol for Mathematics contributed mainly to the validity of the prediction model, the question raised during the literature study regarding the reliability of the results from former DET schools arises again.

It is not worthwhile to include the final step of the prediction model, as it does not contribute significantly to the validity of the model.

The final prediction model is: **$\hat{y}$= 25.675 + 0.656 (Mathematics) + 10.668 (Mental Alertness) - 4.060 (Vocabulary) - 2.056 (Creativity)**

Table 12.14: Result of multiple regression analysis performed on data, using a final Computer Skills score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Multiple Regression Coefficient	0.361	0.537	0.552	0.578	0.621	0.672
R-Square	0.131	0.288	0.305	0.334	0.386	0.451
Standard Error of Estimate	9.451	8.568	8.482	8.317	7.999	7.580
F-Ratio	41.146	55.253	39.751	33.991	33.981	36.827
Degrees of Freedom	1,274	2,273	3,272	4,271	5,270	6,269
p-level	0.000	0.000	0.000	0.000	0.000	0.000
Constant	52.397	60.786	59.399	79.629	86.692	83.264
Mental Alertness	3.033	5.424	5.367	4.622	4.812	4.250
Reading Comprehension		-4.746	-5.080	-5.047	-5.203	-5.536
Composition of Wholes			0.286	0.322	0.314	0.286
Creativity				-1.443	-2.476	-3.083
Spatial Reasoning					4.602	7.980
Numerical Ability						-4.974

For the criterion variable ***Computer Skills*** for Mechanical Engineering Technology R=0.672 and 45.1% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The greatest contribution to the prediction of a final mark for the subject Computer Skills for Mechanical Engineering Technology was made by the predictor variable **Mental Alertness** (β= 0.579). The general mental ability associated with performance on this index, thus seems to have influenced the performance of students in the subject Computer Skills.

The addition of the performance of students on the **Spatial Reasoning** index (β= 0.499) further enhanced the predictive validity of the assessment battery for the criterion variable Computer Skills. Those students who displayed the competency to perceive, analyse and synthesise, as well as the ability to select and categorise were thus the students with the highest probability of being successful in the subject Computer Skills. The addition of the performance on the **Composition of Wholes** index (β= 0.345) further significantly contributed to the prediction model.

Significant negative relations were found to exist between the criterion variable and performances on the predictor variables **Creativity**, **Reading Comprehension** and **Numerical Ability**.

A high score on the criterion variable Computer Skills for Mechanical Engineering Technology is associated with high scores on the Mental Alertness, Spatial Reasoning and Composition of Wholes indices and low scores on the Creativity, Reading Comprehension and Numerical Ability indices.

The F Ratio in step 6 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.66, and 44.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents, R = 0.69, and 47.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 7.58 if the prediction model is applied to the

whole group, which, even though high, is still lower than it would have been if only Grade 12 performance in Mathematics and Science were used.

The standard error of estimate alters marginally if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 7.65 and for the Black group the standard error of estimate = 7.39. The percentage of White students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 0.26% higher than that of the Black group.

As the addition of the final step increases with almost 6.5% the percentage of variance in the performance on the criterion variable explained, the sixth step is included in the prediction model.

The final model is: $\hat{y}$= **83.264 + 4.250 (Mental Alertness) - 5.536 (Reading Comprehension) + 0.286 (Composition of Wholes) - 3.083 (Creativity) + 7.980 (Spatial Reasoning) - 4.974 (Numerical Ability)**

Table 12.15 shows that for the criterion variable ***Mathematics*** for Mechanical Engineering Technology, R = 0.680, and 46.3% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model.

The Grade 12 symbol obtained for **Mathematics** (β= 0.558) made the greatest contribution to the prediction of the final Mathematics score obtained by the students. However, by adding the performance of the students on the **Numerical Ability** index (β= 0.200) of the Visual Potential Index Batteries to the prediction, the predictive validity of the assessment battery for the Mathematics score obtained by Mechanical Engineering Technology students was significantly increased.

A significant inverted relation was found to exist between the performance on the criterion variable and the performances on the **Reading Comprehension** index.

Table 12.15: Result of multiple regression analysis performed on data, using a final Mathematics score for Mechanical Engineering Technology as criterion.

	Step 1	Step 2	Step 3	Step 4	Step 5
Multiple Regression Coefficient	0.587	0.636	0.667	0.671	0.680
R-Square	0.345	0.404	0.444	0.450	0.463
Standard Error of Estimate	10.122	9.674	9.357	9.329	9.253
F-Ratio	144.326	92.508	72.523	55.377	38.592
Degrees of Freedom	1,274	2,273	3,272	4,271	5,270
p-level	0.000	0.000	0.000	0.000	0.000
Constant	-11.563	3.025	-9.281	-7.545	-6.964
Mathematics	0.897	0.834	0.834	0.856	0.826
Reading Comprehension		-2.950	-2.650	-2.295	-2.893
Numerical Ability			3.435	4.058	4.029
Spatial Reasoning				-2.024	-2.606
Mental Alertness					1.016

A student who scored high on Grade 12 Mathematics and on the Numerical Ability index and who scored low on the Reading Comprehension index can thus be expected to have a high Mathematics score.

The F Ratio in step 5 is statistically significant on the 0.1% level, thus indicating a significant relation between the performance on the predictor variables and the criterion variable.

If the prediction model is applied to the major cultural groups separately, the multiple regression coefficient for the White respondents equals 0.71, and 48.9% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For the Black respondents, R = 0.63, and 41.2% of the variance in the criterion variable can be explained by the variance in the predictor variables included in the prediction model. For both groups, the F value remains statistically significant on the 0.1% level.

The standard error of estimate = 9.25 for the total group, which indicates that the predicted performance differs 9.25% on average from the observed performance. This implies a high percentage of applicants being rejected wrongly as well as the same percentage being admitted wrongly if only these predictors were to be used. It still is lower, however, than it would have been if only Grade 12 symbols for Mathematics and Physical Science were used (standard error of estimate = 10.12). The high error of estimate could again be explained by the issue of the use of symbols representing a range of possible performances already mentioned.

The standard error of estimate alters marginally if the prediction model is applied to the main cultural groups separately. For the White group, the standard error of estimate = 8.25 and for the Black group the standard error of estimate =10.78. The percentage of Black students that would be wrongly admitted as well as wrongly rejected if this model were to be implemented unchanged, is 2.53% higher than that of the White group. As the Grade 12 symbol for Mathematics contributed mainly to the validity of the prediction model, the question raised during the literature study regarding the reliability of the results from former DET schools, arises once again.

The final two steps of the model do not contribute significantly to the validity of the prediction model and can thus be omitted.

The final model is: **$\hat{y}$= –9.281 + 0.834 (Mathematics) - 2.650 (Reading Comprehension) + 3.435 (Spatial Reasoning)**

12.4.2 Summary of results found for Mechanical Engineering Technology

From the above it is clear that specific predictor variables played a significant role in the prediction of performance for more than one subject in the Mechanical Engineering Technology course.

The Grade 12 Mathematics symbol consistently made a contribution to the prediction of success in the Mechanical Engineering Technology programme. This finding corresponds with the general finding reported in Chapter 6, namely, that school performance remains a good predictor of higher education academic performance. The Grade 12 Physical Science symbol does not perform as well as a valid predictor for success in the Mechanical Engineering Technology programme.

The addition of the performance on the Numerical Ability index seems to enhance the predictive validity of the assessment battery for Mechanical Engineering Technology in at least four subjects. In view of the fact that the reliability of this index was shown earlier to be lower than expected, its predictive validity would possibly be higher if the reliability could be improved.

The performance of the students on the Mental Alertness index further added to the predictive validity of the assessment battery, as it showed significant correlation with the final average score as well as with various individual subjects in the Mechanical Engineering Technology programme.

The Spatial Reasoning index correlated significantly with some subjects, but

reversed relations with other were recorded.

12.5 Conclusion

The results of the statistical analysis performed on the data were presented in this chapter. It seems as if the proposed assessment battery has a higher predictive validity than has the use of the Grade 12 Mathematics and Physical Science symbols only for selection purposes. The conclusions drawn from these results are presented in Chapter 13, together with specific recommendations regarding the implementation of the potential assessment battery.

Chapter 13

Conclusions and recommendations

13.1 Introduction

Since the results of the study were presented and discussed in the previous chapter, this chapter contains the conclusions drawn from the literature study and research findings. Furthermore recommendations will be made towards future research and the possible development and refining of the suggested assessment battery.

13.2 Conclusions

This study addressed the need for a valid, accurate and efficient tool for the selection of Engineering Technology students. From the research findings and literature study the following deductions regarding the suggested potential assessment battery can be made:

13.2.1 The results of the study revealed that the accurate selection of Engineering Technology students is possible to a satisfactory extent.

13.2.2 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.

The incorporation of the suggested potential assessment battery in the selection process will thus contribute to increased and broadened participation in higher education as prescribed by the White Paper on Higher Education (DOE, 1997:8) and confirmed by the National Plan for Higher Education (Ministry of Education, 2001:15), as it will give students who were previously excluded on the grounds of school performance an opportunity to be included in higher education . The development of alternative selection methods that make higher education more accessible for different race groups is therefore in accordance with the guidelines set for the transformation of higher education by the Department of Education (DOE, 1997:8). Such a potential assessment system will furthermore support the vision of the Ministry of Education to develop a system of higher education that will promote equity of access, while eradicating most, if not all, forms of unfair discrimination, as discussed in Chapter 2.

13.2.3 The results of the statistical analysis performed on the research data proved that not all the indices included in the potential assessment process made a significant contribution to the prediction of academic performance in the Engineering Technology courses. However, some of the indices of the Potential Index Batteries did make consistent contributions to the prediction of performance in the Engineering Technology courses. Table 13.1 contains a matrix that indicates which variable predicted performance on which criterion variable.

13.2.5 It is also clear from Table 13.1 that different indices from the Potential Index Batteries played a significant role in the prediction of performance in the Civil Engineering and Mechanical Engineering Technology courses, respectively. This finding confirms the concept of situation-specific selection, as proposed by the developers of the Potential Index Batteries and discussed in Chapter 7.

13.2.6 The Potential Index Batteries were found to be both reliable and valid in general. It was furthermore proved that they were not biased against any population group included in this study.

13.2.7 A disturbingly high standard error of estimate was found throughout the study. This could possibly be ascribed to the unreliability of the criterion scores used in the study, which might be explained by the fact that the academic results of students were obtained over a three-year period.

13.2.8 This study does not claim to say the final word for the selection of Engineering Technology students. It has however strengthened the validity and fairness of the selection procedures and increased the possibility for selection transparency. The research indicated the areas in which the selection mechanism was valid, but also the aspects of it that were not justifiable.

13.3 Recommendations

The following recommendations are made from the conclusions that have been drawn:

13.3.1 Even though the Grade 12 symbol for Mathematics of the students from the former DET schools did not have as high a predictive validity as had been expected, the concept of prior knowledge of Mathematics, as predictor of academic success in engineering courses, and as represented by the symbol obtained in the final high school examination, should not be negated. The fact that the current matriculation system will be replaced by the Further Education Training Certificate (FECT) also has an impact. The exact

format of the final results of this system is currently unknown and the predictive validity of the new end-of-school results will have to be investigated before they can be used for selection purposes. This situation emphasises the need for higher education institutions to develop and validate their own instruments and policies. It is recommended that the initiative to develop an in-house Mathematics and Science admission test, as Technikon Pretoria is currently doing, should be investigated further and that the reliability and validity of such an admission test be established empirically. This admission test should, in conjunction with the potential assessment battery suggested by this study, form the core of the selection procedure for Civil and Mechanical Engineering Technology students at Technikon Pretoria.

13.3.2 It is recommended that the potential assessment battery for Civil Engineering Technology should consist at least of Creativity, Mental Alertness, Numerical Ability, Composition of Wholes and Perception. The battery for Mechanical Engineering Technology should at least include Creativity, Reading Comprehension, Mental Alertness, Numerical Ability, Composition of Wholes and Spatial Reasoning.

13.3.3 As an alternative, it is proposed that all prospective Engineering Technology students be evaluated with the same battery and that different weights be allocated to different indices, as determined by the prediction models. It would then be possible to implement an advisory selection system, where the most suitable course for a candidate, according to his or her potential profile, could be recommended.

13.3.4 It is furthermore recommended that this study be repeated for the Electrical and Industrial Engineering Technology courses in order to establish prediction models for those courses, to ensure that the

	Creativity	Reading Comprehension	Mental Alertness	Vocabulary	Numerical Ability	Composition of Wholes	Spatial Reasoning	Perception	Mathematics	Physical Science
Final Average (C)	X		X		X	X		X	X	
Drawing (C)	X					X		X	X	
Mathematics (C)	X	X	X			X			X	X
Construction Materials (C)	X				X					
Applied Mechanics (C)	X					X	X	X	X	
Final Average (M)		X	X	X		X			X	
Electro-Technology (M)	X	X	X		X	X	X	X	X	
Communication Skills (M)	X	X	X			X	X			
Drawing (M)	X	X		X	X	X	X			
Manufacturing Engineering (M)	X				X					
Mechanics (M)	X		X	X					X	
Computer Skills (M)	X	X	X		X	X	X			
Mathematics (M)		X			X				X	

C = Civil Engineering Technology
M = Mechanical Engineering Technology

Table 13.1: Matrix of variables that played a role in the prediction of performance on the criterion variables

advisory selection process functions optimally.

13.3.5 The possibility of expanding the potential assessment battery to include other predictors that were not included in this study should be investigated.

13.3.6 The reliability and consistency of the criterion scores used in this study are questioned and the way in which marks are allocated in the various academic subjects should be investigated.

13.3.7 If the Potential Assessment Battery is to be used in a selection context where the characteristics of the applicant pool differ from the sample used here, or where the programme for which students are selected differs significantly from the Engineering Technology courses used as criterion variables in this study, the effectiveness and fairness of the potential assessment test will have to be re-evaluated for the new context.

13.3.8 Since predictions involving short time spans (e.g. weeks or months) usually are more accurate than those where there is a long time span between the assessment of the predictor and criterion variables (Mc Millan & Schumacher, 1993:275) it is recommended that a study is undertaken to monitor the eventual success of students admitted by means of the selection procedure suggested here.

13.4 Limitations of this study

The execution of this study posed specific limitations that are discussed below.

13.4.1 No aptitude or potential test will ever correlate perfectly with academic performance, because motivation and effort always play

a role as well (Huysamen, 1997:68). The validity of the prediction model was most likely negatively affected by the fact that these factors were not taken into consideration or included in the contingent of possible predictors,

13.4.2 As only students who had already been admitted to the various Engineering Technology courses were included in the sample, the study was performed on a pre-selected group. The range of scores on the predictor variables was confined to a representation of only a part of the total distribution of that variable, and this restriction in range could have led to a lowering of the correlation. McMillan and Shumacher (1993:277) state that restriction in range partially explains the usually modest relationship between college admission tests and academic achievement - the range is restricted to those students who achieved high scores in the admission tests.

13.4.3 It could be argued that academic performance is not the only relevant measurement when it comes to the selection of students. Issues such as performance on the actual job could also be regarded as relevant. The counter argument could be that a student who will not be successful in the job market should not pass the course.

As this study was initiated to address the specific problem of admitting students to higher education, academic success was deemed criterion enough. Future studies could focus on the predictive validity for performance in the labour market of the suggested selection battery used in this study .

13.4.4 Since a nonprobability convenience sample was selected for this study, the results could not have been generalised from sample to population, as the sampling error could not be determined. The results of this study are thus valid only for the selection of Civil and

Mechanical Engineering Technology students at Technikon Pretoria.