PREDICTING AVERAGE MARKS IN TERTIARY EDUCATION USING COGNITIVE TESTING AND SECONDARY EDUCATION PERFORMANCE

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ABSTRACT

South Africa faces several challenges in higher education including numbers of graduates following drives for mass participation. This is a complex problem of which selections are one component. This institution uses the PIBSpEEx as an adjunct to grade 12 results in selections. The predictive power of this instrument and secondary schooling results was investigated in relation to 'success' in the form of average marks as well as a pass-fail model. Results indicated statistical significance for secondary schooling and sub-tests of the PIBSpEEx although effect sizes were not as expected given international research. This questions which aspects of cognition, education and selection procedures should be considered to select students with a higher likelihood of success in the South African context.

Keywords: cognitive assessment, higher education, intelligence, PIBSpEEx, predicting tertiary education performance

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In 2009, approximately 521,430 students were enrolled in contact classes in their first year of study at one of South Africa's Higher Education Institutions (HEI's) (Department of Basic Education, 2010). By 2011 the number of enrolled students had risen to around 556,695 (Department of Higher Education and Training, 2013). In 2011, approximately one half of tertiary education students were enrolled for degree programs, with around one third being enrolled at Universities of Technology for National Diploma or Higher Certificate training programs of a more practical nature. The remaining students were enrolled for post-graduate Masters and Doctoral courses. This number approximately reflected the previous year's enrolment target (Bunting, Sheppard, Cloete, & Belding, 2010). The enrolment target was specified in line with the promotion of mass participation relevant to students carrying a full credit load. Despite these efforts, and a doubling of the number of institutions over the 20 years, sub-Saharan Africa evidenced considerably lower enrolment rates than World averages reflecting enrolments of 6% of the population versus 26% respectively (Montanini, 2013).

Success and graduation rates at South African HEI's may be reported in a variety of ways. Bunting et al. (2010) report success rates based on accumulated credits divided by headcount. These authors report a success rate of 80% at contact institutions in the year 2000. This represents an increase of 7% since the year 2000 and is in line with the national targets. However, Letseka and Malle (2008) reported that approximately 16% of students enrolled for the first year of undergraduate study (degree or diploma) had successfully graduated within three years. In this case only three year courses were considered. Around 30% of the studied students had dropped out prior to completion of their first year of study. In their report regarding the transformation of higher education for the Centre for Higher Education Transformation, Bunting et al. (2010) reported enrolment and success rates between the years 2000 and 2008. Examination of these figures indicated that the balance of graduates to enrolments was generally around 10%-12% across any given time period. Both graduate and enrolment rates had increased in number between 2000 and 2008. However, Bunting et al. (2010) caution that post-graduate studies, which can take a considerable length of time, were included in these numbers. Furthermore, in 2011, the South African Department of Higher Education and Training reported on graduation rates for that time period. In that year, approximately 160,000 students received a Degree or Diploma from a public HEI, evidencing a graduation rate of approximately 25% for the 2011 cohort.

From these figures, it would appear that certain aspects of promotion of access to Higher Education have been met. The national figures appear to match demographic profiles of the country, despite histories of disadvantage and lack of access to tertiary education (Bunting, Sheppard, Cloete, & Belding, 2010). However, graduation rates evidenced between different demographic groups are still notable. Clear inequalities appear to exist in likelihood of success dependent upon demographic groupings

(Department of Higher Education and Training, 2013). The root cause(s) of this issue are a complex topic which is likely to impact all facets of higher education functions, including support methods, learning tools, financial factors and even selection methods utilised in admissions. Additional factors such as deliberate streaming to foundation programs and identifying support needs may also contribute to likelihood of success.

South African public HEI's currently focus primarily on secondary schooling results (Academic Points Scores or APS) as the primary method of selection into Higher Education Institutions. In some cases these scores are also utilised to stream students into foundation (additional year) programs designed to remediate any inequalities in secondary education schooling. The success of secondary schooling education as an indicator of success in tertiary education is influenced by additional factors such as teaching quality, curriculum developments and the ward in which a school is located. Such factors make APS a potentially unreliable indicator of later achievement, particularly since selection is complicated by large numbers of students with similar scores. Cognitive assessments may provide an effective adjunct to APS in identifying potential in applicants, allowing clearer differentiation between students with similar secondary schooling results or who have received sub-standard secondary schooling. Institutions in a variety of countries are investigating additional or adjunct selection methods. For example, English language assessments which have been demonstrated as influential in multi-lingual countries (Al-Nasir & Robertson, 2001; Ross, 2010; Karakaya & Tavsancil, 2008). Cognitive and learning potential assessments, as well as academic-type assessments have also been considered as potential predictors of higher education success (Hartas, Lindsay, & Daniel, 2008). Although some international research exists to support the use of adjunct assessments, the use of cognitive assessment procedures for selection in developing countries has not been as thoroughly explored. Differential qualities of schooling in countries such as South Africa (Cliff & Hanslo, 2009), and difficulties in the interpretation of cognitive assessments for selection in developing countries given socio-economic and educational factors (Nettle, 2003), make such interpretations difficult and in need of further discussion. It is difficult to disentangle the multitude of relevant variables in order to come to a definitive conclusion as to the most effective method of selection. Discussion of the components which may be involved in selection, in this case cognitive testing, should be discussed in light of a number of extraneous and contributing variables. Discussions should bear in mind the unique challenges experienced by many South African institutions and students. However, when selecting for limited space in HEI's, selection criteria, and potential adjuncts for the improvement of selection procedures, cannot be ignored. The efficacy of traditional and adjunct selection criteria (such as cognitive assessments) needs to be scrutinised whilst holding for demographic factors which may also impact success rates. The question as to the efficacy of cognitive instruments in the South African context specifically is a complex one which requires investigation of each component of success individually and interactively.

LITERATURE REVIEW

Tertiary study acts as a valuable tool in social and economic development on both the micro and macro levels (Kongolo & Imenda, 2012). Education acts as a certification method allowing entry into the global economy through pursuit of specific careers (Herman, 2010). In South Africa, a shortage of skills in the labour market has been identified (Letseka & Malle, 2008). Shortages are compounded by difficulties in breadth of access to higher education, particularly for previously disadvantaged groupings (Boughey, 2003). A large number of factors have been identified as impacting both the likelihood of students entering tertiary education and the likelihood of students exiting HEI's with a qualification.

Predicting success in tertiary education is challenging, partially due to varying selection foci and factors impacting success. International studies of a wide variety of environmental and intrapersonal factors have found only around 4% to 6.5% of variance in academic performance has been explicable (Bauer & Liang, 2003). Factors have included family background (Chapman, Lambourne, & Silva, 1990; Hoogerheide, Block, & Thurik, 2012), culture, gender and socio-economic status (controlling for ability) (Cronbach, 1984; Sewell, 1971). In South Africa and Southern Africa language of instruction and career choice have also been identified in addition to the factors emerging from international research (Mdepa & Tshiwula, 2012). Various intrapersonal factors such as personality, conscientiousness and cognitive ability have also been considered (Busato, Prins, Elshout, & Hamaker, 2000). International studies focusing on low socio-economic children have identified factors such as attention, working memory and meta-cognitive control as being less developed. This may potentially result in the poorer academic performance seen in both secondary and tertiary study. However, concomitant underdevelopment in language skills was also noted as an important factor, leading to questions as to which variables play a larger role in educational outcomes (Jednoro, et al., 2012). Cognitive factors are often cultivated through home and educational environments, creating a dissimilar expression of similar base levels in achievement and academic testing (Busato, Prins, Elshout, & Hamaker, 2000). This is compounded by additional factors specific to the South African context which also have a strong impact on likelihood of success. However, a comprehensive exploration of the experiences of previously disadvantaged students in tertiary education did not lead to conclusive findings. This research, conducted by Malefo (2000), examined stress and coping as primary variables, as well as considering the impact of family environments of previously disadvantaged students who were enrolled at historically disadvantaged institutions. Despite these inconclusive findings, Malefo (2000) did identify a number of important and significant factors in educational outcomes. Older students achieved better, for example, as did students with clearly defined limits within the home environment. Additionally, students with a tendency to use problem-solving focused coping mechanisms were more likely to succeed. Contrary to much international research, the Malefo (2000) research did not find a statistically significant relationship between either socio-economic status or occupational status of parents with academic success. Other research focusing on lecturer perceptions and student perceptions of factors intrinsic to success has also provided valuable information, particularly when pre-enrolment and post-enrolment factors are examined. Findings that strong correlations exist between student and lecturer perceptions of reasons for success, whilst weak correlations exist as to reasons for failure point to additional factors impacting success once within the institution. Whilst perceptions of the "successful" student pointed towards a self-motivated, hardworking and independent student with a satisfactory career choice, lecturers' perceptions of a student likely to fail differed to that of the students' own perceptions. Lecturers' perceptions of failure seemed to relate primarily to student characteristics such as the lack of ability to perform in exams, failure to balance study and social commitments and an over-commitment to family and work demands. Some aspects contributing to failure were agreed upon by both groups and reflected in other international and South African literature, namely, language of instruction/textbooks and career choice (Fraser & Killen, 2005; Mdepa & Tshiwula, 2012).

It is clear that success in tertiary education is related to a broad variety of factors of which previous academic performance and current cognitive function are only two. However, a number of arguments have been put forward for recognition of cognitive potential as a predictor of academic success, particularly in countries like South Africa with differential qualities of secondary schooling and university preparation (Cliffordson, 2008; Cliff & Hanslo, 2009). Some organisations, such as the United Kingdom's Sutton Trust, have argued for academic and non-academic assessments. These include interviews, cognitive testing, additional achievement tests and similar techniques with a focus on admissions and developmental purposes (West & Gibbs, 2004). Some institutions have found this method to be marginally more successful in predicting success than the traditional use of Grade 12 or matriculate results alone. This is particularly true for multi-lingual countries if these types of predictors are used alongside assessments of English for Academic Purposes (Al-Nasir & Robertson, 2001; Ross, 2010; Karakaya & Tavsancil, 2008).

Both academic achievement and cognitive assessments have been used successfully in predicting academic performance and/or potential (Hartas, Lindsay, & Daniel, 2008). However, cognitive intelligence tests are often inappropriately used as a primary indicator of potential for success, failing to account for cultural experience and opportunity to develop required skills (Callahan, 2005). Assessments of skills and abilities, particularly English for Educational Purposes, have been utilised in South Africa, and elsewhere, fairly successfully (Cliff & Hanslo, 2009). In multi-lingual countries, non-verbal assessments and 'learning potential' assessments have proven fairly effective (Lohman, 2005). The concepts of cognition, intelligence and learning potential are somewhat intertwined and may be useful as an adjunct to purely academic selection criteria, as has been considered in some research.

Intelligence testing is often utilised for selection into elite educational programs, bursary allocations and developmental opportunities (White, n.d.). However, relationships between academic success and intelligence may also be a by-product of selection on the basis of cognitive testing (Neisser, 1997). There is a lack of a clear understanding of the relationship between academic success and cognitive assessment results, particularly in light of environmental influences such as familial motivation, parenting, test-wiseness and teaching methods. For example, higher intelligence parents may produce children with higher achievement orientations. This orientation correlates with the acceptance of more productive educational opportunities and, by extension, may increase scoring on intelligence tests. It remains unclear whether measurable cognitive conceptualisations of intelligence truly play a role in schooling achievement. Therefore, this method is subject to similar limitations as previously mentioned factors in predicting academic success. For example, parental socioeconomic status is often related to intelligence assessment scores, social class and offspring's academic achievement (Nettle, 2003) and educational background and schooling can influence performance on standardised cognitive assessments (Klein, Pohl, & Ndagijimana, 2007) creating difficulties in predicting academic performance in groupings with diverse backgrounds.

In the South African context, concepts of culture fairness, in both ability/ achievement tests and cognitive assessments, have been at the forefront particularly regarding issues of language and test-familiarity impacting the potential placement of students in institutions. Nevertheless, concrete evidence of cultural bias is difficult to obtain, despite observations of performance discrepancies between cultural groups (Verney, Granholm, Marshall, Malcame, & Saccuzzo, 2005). The same applies to members of the different socio-economic groupings (Nettle, 2003). Since a large number of factors, both intra- and inter-personal, impact performance on both cognitive assessments and academic study, the debate is likely to continue. However, the majority of modern cognitive assessments are applicable in a variety of contexts, including educational, for persons from a variety of cultural and socio-economic backgrounds (Serpell, 2000; Foxcroft & Roodt, 2005). This research considers the efficacy of the PIBSpEEx (a cognitive instrument) as a potential cognitive/ intelligence predictor of tertiary education attainment along with the traditional secondary schooling results (APS). Despite difficulties in test design and usage, cognitive assessments remain a popular method of identifying potential in modern society.

Although cognitive assessments are grounded in empirical methodologies, a number of theories and perspectives exist. These perspectives primarily relate to the definition of the global concepts of verbal and non-verbal intelligence, memory and working memory as interrelated concepts (Azarmi, Jahangard, & Movassagh, 2012). In line with attempts to eliminate the aforementioned biases, the PIBSpEEx instrument is designed to assess verbal and non-verbal concepts without the interference of cultural bias or educational level (Erasmus, 2004). This instrument reflects a number of factors common to the majority of cognitive intelligence assessments. These include the capacity to learn and apply new information (Sternberg & Pretz, 2005), mathematical-logical abilities (Gardner in Azarmi et al., 2012), encoding of information and eduction of correlates (application of inferred rules) (Sternberg & Pretz, 2005) as well as meta-cognition, the overarching monitoring of information, decision making and logical rules (Azarmi, Jahangard, & Movassagh, 2012). Although definitions of cognitive intelligence are often grounded in psychometric statistical methods, in other words, intelligence is what intelligence tests measure (Cronbach, 1984), general application of measures such as the PIBSpEEx have been demonstrated statistically to be applicable in predicting performance in a variety of contexts based on learning potential (Erasmus, 2004; Anastasi & Urbina, 1997; Foxcroft & Roodt, 2005).

Concepts of ‘learning potential’ have permeated intelligence and cognitive testing in an effort to identify individuals able to profit fully from focused training (Cronbach, 1984). The cognitive processes adopted during tests of cognitive ability rely on the learning of new concepts and information during the test. This learning may reflect maturity of cognition, a characteristic desirable in selecting high-potential candidates (Dillon & Schmeck, 1983). Tests of cognitive potential may be useful in selecting high ‘learning potential’ candidates for tertiary education – a concept which may encompass both intelligence and cognitive maturity in both the verbal and non-verbal spheres. These relationships may be, in part, due to more advanced meta-cognitive skills seen in high potential candidates. In addition to meta-cognition, studies have demonstrated that verbal and non-verbal intelligence are related to successful performance despite being prone to language proficiency biases (Lohman, 2005). Verbal and numerical items have demonstrated higher correlations with academic success than non-verbal items (Lohman, 2005). Regardless of the type of items used in cognitive assessments, it is also clear that the assessment of potential for academic study cannot be separated from necessary minimum levels of academic proficiency, complicating tasks of attempting to separate poor quality of secondary schooling from potential for further study (Haeck, Yeld, Conradie, Robertson, & Shall, 1997)

Currently, the important aptitudes for future success in education systems are current achievement in the relevant domain (as reflected by final secondary school results) and the ability to reason using a symbol system within which the new knowledge will be communicated (this ability is related to complex verbal and numerical abilities as well as ‘fluid’ or de-contextualised intelligence) (Lohman, 2005). In this investigation, the PIBSpEEx and APS were focused on as individual predictors and dual predictors. The APS alone or alongside the PIBSpEEx are used by this institution in the selection of students for admission. It is essential to understand whether or not the two types of assessment are able to statistically predict tertiary results effectively and, if so, to what extent. Therefore, the primary focus of the study was an analysis of the psychometric properties and potential statistical predictive power of the instrument and APS. A statistical focus is typical of studies in this area and is generally followed by more qualitative consideration of the instrument's scales (Cronbach, 1984; Anastasi & Urbina, 1997). Follow up theoretical considerations of an instrument's items and scales are useful in assessing the importance of specific skills inherent in the instrument. The complete statistical investigation rested on a basic research question: Can APS and PIBSpEEx scores predict tertiary education outcomes in National Diploma students at a University of Technology? Consideration of the content of the scales, along with emerging extraneous variables, was intended to be the focus of a discussion of the statistical findings. This aim was intended to facilitate understanding of the statistical findings and to identify potentially useful additional predictors.

METHODS

The study was grounded in an empirical quantitative design and data type. As a descriptive and correlational study, archival data was collected and analysed without manipulation or alteration except in the respect of missing data (see "Data and Sampling"). Prior to commencement of the study, ethical clearance was obtained from the relevant institutional ethics committees (departmental and institutional). In addition, permission was obtained from the Registrar for the use of institutional data. All students who completed the assessment underwent a verbal informed consent procedure. During the informed consent procedure, the possibility of utilisation of results in research was discussed and agreed to. All data utilised was archival and remained confidential and in the care of the researcher with limited access. The data was anonymised prior to analyses and no personal information was utilised for reporting purposes.

Data and sampling

The final sample consisted of National Diploma students and applicants at a University of Technology in South Africa. Archival data from the 2010 and 2011 intake applications was obtained, consisting of students who were : (a) enrolled at the institution; (b) had written the PIBSpEEx assessment but were not accepted or had not enrolled or; (c) had written the PIBSpEEx assessment and enrolled at the institution. Since not all students or applicants had written the assessment for admissions and not all of those who wrote the assessment were admitted, a multiple imputation procedure (Rubin's) with five iterations was utilised in order to compensate for missing data in the independent variables. Missing demographic data was not imputed. In this case, approximately two-thirds of the PIBSpEEx scores were missing within the total sample. Rubin's multiple imputations allows for the imputing of *m* number of missing values (in this case for five iterations). The data set is then complete and allows for full statistical analysis without the shortfalls involved in uneven group numbers or large amounts of missing data (Hunt, Lunneborg, & Lewis, 1975). Unfortunately, this method has several short-falls. Firstly, the accuracy of the imputed data, despite being within the required ranges, is unknown. Although the imputed model should fit the aspects of the various distributions relevant for analysis, the data will still be subject to sampling variability (von Hippel, 2012). This is likely to reduce the statistical power evidenced making it less likely that a 'real world' effect will be evidenced. It is possible that a study utilising imputed data may produce lower effect sizes than a similar study consisting of a full original data set. As a result, the weaknesses involved in utilising multiple imputations in this study were fairly evident during analysis and discussion. The interpretation of correlation coefficient and effect sizes produced should be examined bearing in mind the aforementioned limitation. Multiple imputation procedures do account for missing data from a statistical perspective but fail to account for range restriction. Range restriction was an unavoidable by-product of the sample obtained. This is as a result of applicants and accepted students being required to meet the institution's minimum requirements. Additionally, only a limited number of students, often within a restricted APS bracket, were required to write the PIBSpEEx assessment. Range restrictions may impact the strength of correlation coefficients and the magnitude of effect sizes. Generally these statistics are likely to be less accurate in either direction when range restriction is present (Howitt & Cramer, 2011).

Demographic data was only obtainable for groups (a) and (c), indicating a fairly equal split between Males (54.40%) and females (45.60%) and the majority of students (>45% in total) belonging to the North Sotho, Tswana and Zulu ethnic groups. These same languages were spoken by the majority of students. Sample sizes varied depending upon the variable examined producing a grand total of over 4000 cases. Tables 1 and 2 summarise the demographic profile of the sample.

Table 1: Demographic information

2010				2011			
		n	%			*n*	%
Gender	Female	2286	54.40%	Gender	Female	2462	52.20%
	Male	1916	45.60%		Male	2257	47.80%
Ethnic Group	North Sotho	976	23.20%	Ethnic Group	North Sotho	1004	21.30%
	Tswana	559	13.30%		Tswana	641	13.60%
	African	469	11.20%		Zulu	520	11.00%
	Zulu	411	9.80%		Tsonga	474	10.00%
	Tsonga	393	9.40%		Swati	440	9.30%
	White	363	8.60%		White	373	7.90%
	Swati	252	6.00%		African	298	6.30%
	Ndebele	222	5.30%		Ndebele	259	5.50%
	South Sotho	183	4.40%		South Sotho	231	4.90%
	Venda	174	4.10%		Venda	184	3.90%
	Xhosa	139	3.30%		Xhosa	176	3.70%
	Coloured	35	0.80%		Pedi	67	1.40%
	Indian	17	0.40%		Coloured	38	0.80%
	Pedi	9	0.20%		Indian	14	0.30%
Language	North Sotho	1093	26.00%	Language	North Sotho	1069	22.70%
	Setswana	573	13.60%		Setswana	670	14.20%
	Zulu	466	11.10%		Zulu	595	12.60%
	Tsonga/ Sjangaan	359	8.50%		Swazi	456	9.70%
	Swazi	348	8.30%		Tsonga/ Sjangaan	345	7.30%
	Afrikaans	296	7.00%		Afrikaans	295	6.30%
	English	255	6.10%		South Sotho	262	5.60%
	Ndebele	201	4.80%		Ndebele	240	5.10%
	Venda	181	4.30%		English	229	4.90%
	South Sotho	180	4.30%		Venda	183	3.90%
	Xhosa	138	3.30%		Xhosa	174	3.70%
	Tsonga	54	1.30%		Tsonga	122	2.60%
	Afrikaans/ English	21	0.50%		Afrikaans/ English	31	0.70%
	French	20	0.50%		French	28	0.6%
	Other	17	0.40%		Other	20	0.4%

Residence	Off Campus	2890	68.80%	Residence	Off Campus	3112	65.90%
	Residency	1312	31.20%		Residency	1607	34.10%
Bursary	Bursary or Funding	2183	52.00%	Bursary	Bursary or Funding	2909	61.60%
	None	2019	48.00%		None	1810	38.40%

Table 2: APS and average marks

2010					**2011**				
	n	***Max***	***Min***	***Mean***		***n***	***Max***	***Min***	***Mean***
Age	4202	61	19	23	Age	4719	51	17	22
APS Score	4202	50	5	23	APS Score	4719	77	5	25

Instruments

PIBSpEEx battery

The Potential Index Batteries and Situation Specific Evaluation Expert scales (PIBSpEEx) provide a comprehensive assessment package for assessing human potential in a culture fair manner and allowing for secondary education levels of less than Grade 12 (Erasmus, 2004). The cognitive scales utilised in this study consider constructs of potential divided into broad areas of intelligence, namely, Conceptualisation (integration on visual information), Mental Alertness (understanding of implied differences in English words), Calculations (based on word and series problems), Observance (understanding of implied differences in pictorial information), Reading Comprehension with a memorisation component, Insight (the ability to infer and manipulate verbal information) and Object Assembly (spatial reasoning and manipulation). The assessment consists of forced choice options with a timed component, each sub-test being timed separately for a total of approximately 1 ½ hours of testing. When first instituted at this institution the instrument accounted for between 60% and 90% of variance in academic performance of National Diploma students. Criterion validity coefficients at this time ranged between .34 and .68 being significant at either the .05 or .01 level. Inter-item consistency reliability coefficients utilising the Kuder-Richardson formula ranged from .68 to .87 (Kriel, 2002).

Academic points scores

Academic point scores are based on levels of achievement in Grade 12 subjects. The scores are based on the percentages achieved in specific subjects during final Grade

12 exams and calculated as follows: Scores are added together for the highest six subjects taken (excluding Life Orientation) to provide a total APS. Candidates must have taken English as a language (home or 1st additional) and either Mathematics or Mathematical Literacy dependent upon the course of study applied for. Points are calculated as follows: 0%-29% = 1; 30%-39% = 2; 40%-49% = 3; 50%-59% = 4; 60%-69% = 5; 70%-79% = 6; 80%-100% = 7.

Average results

Exam averages were calculated based on all subjects taken by the student as an average. Therefore, mid-year and end of year exam results comprised part of the average score. Exam papers are set and marked by the academic departments and lecturers concerned, under the control of the University of Technology. Marks are assigned and averages reflected as a grade out of 100 in the form of a percentage.

RESULTS

Preliminary analyses of instruments

The 2010 and 2011 intakes were analysed separately for the purposes of inferential statistics to better understand potential differences due to year of intake given changing secondary educational standards or other factors.

The PIBSpEEx subscales yield a minimum possible score of 1 with a maximum possible score of 10. The Total Scale is the culmination of the 7 sub scales with a possible range of 7 to 70. The majority of scales fell within normal levels of skewness and kurtosis with only minor deviations from the -1.000 to +1.000 value range in a few cases.

Table 3: Mean scores and descriptive statistics of the PIBSpEEx scales (pooled)

	2010			**2011**		
Scale	***Min***	***Max***	***Mean***	***Min***	***Max***	***Mean***
Conceptualisation	1.020	9.60	5.008	1.000	10.000	4.997
Mental Alertness	1.000	9.300	4.333	1.000	9.220	4.352
Observance	4.510	9.640	6.201	1.000	10.000	6.148
Insight	1.000	9.460	4.153	1.000	10.000	4.251
Calculations	1.000	6.920	3.200	1.000	8.000	3.173
Object Assembly	1.000	10.000	4.454	1.000	10.000	4.398

Reading Comprehension	1.000	9.900	4.628	1.000	9.900	4.640
Total Scale	21.000	42.000	33.517	12.000	53.000	33.114

Reliablity analyses provided Cronbach's Alpha values of α=.697 in the 2010 intake and α= .733 in the 2011 intake. These figures are somewhat lower than generally reported in most studies of the reliability of cognitive assessments (Anastasi & Urbina, 1997). No scale deletions would have caused the values to increase for the Total scale. Item-Total correlations were similar across the seven scales indicated - none appears to be insignificant or over-contributing.

Some differences were observed between the 2010 and 2011 imputed data sets in terms of APS scores. The following table of descriptive statistics was obtained for the pooled results. Some APS scores are below the published level of entry for National Diploma courses but were present in the data obtained from institutional records.

Table 4: Descriptive statistics: APS scores

Year of Entry	*Min*	*Max*	*Mean*	*SD*	*Skewness*	*Kurtosis*
2010	5	50	23.25	4.932	0.135	1.236
2011	5	77	25.17	5.411	1.257	4.432

For both intakes, the majority of cases fell within the 20-28 points bracket. A Log10 transformation produced skewness values closer to normal limits than originally evidenced. Statistics of kurtosis demonstrated a leptokurtic distribution with the majority of values truncated towards the central and lower points of the distribution. This was most probably a product of the range restriction alluded to earlier.

Academic results are the cumulative average of all modules/subjects averaged over all years of study regardless of whether the student has passed or failed. The descriptive statistics produced here apply to the pooled results.

Table 5: Descriptive statistics: Average mark

Year of Entry	*Min*	*Max*	*Mean*	*SD*	*Skewness*	*Kurtosis*
2010	2.400	93.111	53.715	11.133	-0.543	2.030
2011	2.500	95.667	54.562	10.933	-0.622	2.094

Demographic differences in the dependent variables

Significant (p<.05) differences were found in APS, PIBSpEEx scores and average marks for almost all demographic variables. It is unclear as to whether these differences were due to sampling size, error or random fluctuations. In most cases the effect sizes and *PS* (probability of superiority) values obtained were small or approaching 50% in the case of *PS* values. Three specific differences are worth noting as they produced larger effect sizes and *PS* values. Firstly, students who had obtained a Bursary or NSFAS funding were more likely to have higher APS scores and perform better in their first year of tertiary study. The same is true of students living in the residences. These differences held across both the 2010 and 2011 intake for the pooled results. English and Afrikaans students also exhibited higher APS and PIBSpEEx scores. This language difference, however, was only present for the 2011 intake. For the language variable, effect sizes remained small ($\eta^2_{PARTIAL}$=0.017) indicating a possibility that differences were due to sampling or random error.

Prediction of average mark: linear, multiple, stepwise and logistic regressions

Initial correlational analyses (Pearson's r) between the variables produced significant coefficients (p<.05) but relatively small coefficients of determination (<5% in most cases). The initial multiple regression models examined the seven PIBSpEEx scales utilised. These scales were combined as predictors per year of intake producing a significant model for both 2010 (F=13.692, p<.001) and 2011 (F=16.217, p<.001) intakes. Examination of standardised regression coefficients (β) indicated the relative strength of relationship for each predictor in the model with the strongest emerging being the Insight, Observance, Conceptualisation and Reading Comprehension scales. These variables formed the basis for stepwise regression models for both the 2010 and 2011 intakes. The order of entry for the variables was obtained by the creation of multiple regression models with two independent variables in order to ascertain the order of 'contribution' and identify the strongest predictors. Note that when APS was utilised, the Log10 transformed variable was used unless otherwise stated.

The stepwise regression model for the 2010 intake achieved statistical significance (F=26.436, p<.001).

Table 6: Stepwise regression 2010 intake: Three PIBSpEEx scales

Model	R^2	R^2 ***Change***	***F Change***	***p***
1	.012	.012	48.093	.000
2	.018	.006	22.521	.005
3	.019	.002	6.538	.041

Insight
Insight + Observance
Insight + Observance + Conceptualisation

The following standardised regression β values and their relative significance in the predictive model were produced:

Table 7: Stepwise regression: Three PIBSpEEx scales: Standardised β values and significance

	β	***t***	***p***
Insight	0.081	1.711	.146
Observance	0.061	1.738	.127
Conceptualisation	0.042	1.755	.097

*Note: *β indicates the standardised coefficient*

In 2011, the following model achieved statistical significance (F=34.729, p<.001):

Table 8: Stepwise regression 2011 intake: Three PIBSpEEx scales

Model	R^2	R^2 ***Change***	***F Change***	***P***
1	.012	.012	55.163	.000
2	.020	.008	35.908	.006
3	.022	.003	12.468	.077

Observance
Observance + Insight
Observance + Insight + Reading Comprehension

The following standardised β weights and their associated significance were produced for this stepwise model.

Table 9: Stepwise regression: Three PIBSpEEx scales: Standardised β values and significance

	β	*t*	*p*
Observance	0.082	3.645	.003
Insight	0.071	1.493	.196
Reading Comprehension	0.049	1.438	.197

*Note: *β indicates the standardised coefficient*

The results indicate that the addition of the new variables did provide a significant increase to the predictive power of the models (note that Conceptualisation was replaced by Reading Comprehension in the 2011 intake). The remaining four variables (not included in the stepwise models) did not account for much more than an additional 0.3% of variance in either intake. Only the Observance scale achieved statistical significance in the 2011 model.

It appears that the Observance and Insight scales, used as combined predictors, are the strongest predictive variables in the PIBSpEEx instrument when accounting for variance in average mark. Both appear to contribute to the power of the stepwise model in predicting average mark and were therefore utilised as part of the basis when creating a stepwise model which included APS as a predictor variable. Additional variables were then re-selected holding APS as the initial variable with the process of many regression models being re-analysed to again ascertain which variables explained the largest amount of variance and should be included in the second set of models.

Stepwise regression: best predictors of average marks.

Stepwise regression models were created using APS as the initial variable (entered first). The remaining variables were selected by examination of a series of multiple (two predictor) regression models, each adding one PIBSpEEx scale individually (i.e. a series of two variable regression models). The scales explaining the most additional variance in combination with APS were utilised in order of amount of variance explained. For the 2010 intake, the full model was statistically significant (F=46.008, p<.001). The following changes in variance were observed:

Table 10: Stepwise regression 2010 intake: APS and 3 PIBSpEEx scale model

Model	***R^2***	***R^2 Change***	***F Change***	***p***
1	.030	.030	113.138	.000
2	.041	.011	43.862	.000

3	.046	.005	18.746	.023
4	.047	.002	6.364	.048

1. APS
2. APS + Insight
3. APS + Insight + Observance
4. APS + Insight + Observance + Conceptualisation

The individual predictors produced the following standardised regression coefficients and associated levels of significance:

Table 11: Stepwise regression 2010 intake: APS and three PIBSpEEx scales: Standardised β values and significance

	β	***t***	***p***
APS	0.170	10.484	.000
Observance	0.079	1.722	.142
Insight	0.055	1.549	.167
Conceptualisation	0.042	1.698	.109

*Note: *β indicates the standardised coefficient*

The full model explained a total of 4.7% of variance in average mark. Academic points score alone explained 3.0% of the total variance. The introduction of the Insight scale was significant (F=43.862, p<.001), explaining a further 1.1% of variance. Further addition of the Observance scale to the model was also significant (F=18.746, p=.023), albeit at the 5% rather than 1% level and only explaining a further 0.5% of variance. Introduction of the Conceptualisation scale did produce significant change (F=6.364, p=.048), accounting for a further 0.2% of variance. It appears, in the case of this model, that the introduction of the Insight scale alongside APS was fairly useful but introduction of the Observance and Conceptualisation scales did not produce particularly impressive results in terms of percentage of variance explained. Despite the significance of the model and changes in variance explained, only the APS predictor proved statistically significant in this model.

In the 2011 year of entry, the full model utilised APS score, Observance, Insight and Reading Comprehension in that order of priority. The model was statistically significant (F=58.461, p<.001). The following coefficients of determination and changes in variance explained with the introduction of additional predictors were found:

Table 12: Stepwise regression 2011 intake: APS and 3 PIBSpEEx scale model

Model	***R²***	***R² Change***	***F Change***	***p***
1	.030	.030	113.138	.000
2	.037	.007	28.706	.000
3	.046	.009	33.861	.005
4	.048	.002	7.663	.157

1. APS
2. APS + Observance
3. APS + Observance + Insight
4. APS + Observance + Insight + Reading Comprehension

Academic points score described approximately 3.0% of a total of 4.8% of variance. Introduction of the Observance variable was significant (F=28.706, p<.001), explaining a further 0.7% of variance. Introduction of the Insight scale explained an additional 0.9% of variance and was significant (F=33.861, p=.005). However, introducing the Reading Comprehension scale did not produce significant change (F=7.663, p=.157), explaining a further 0.2% of variance. The individual predictors produced the following standardised regression coefficients and associated significance levels:

Table 13: Stepwise regression 2011 intake: APS Log10 and three PIBSpEEx scales: Standardised β values and significance

	β	***t***	***p***
APS	0.174	11.040	.000
Observance	0.068	3.195	.005
Insight	0.052	1.065	.336
Reading Comprehension	0.037	1.122	.300

*Note: *β indicates the standardised coefficient*

The APS variable proved significant. The Observance scale also proved significant at the 1% level. Based on this information, it appears that variance in average mark is attributable primarily to APS and the Observance scale. This is of interest in comparison to the 2010 intake model, in which the introduction of first Insight and then Observance scales were both significant.

In order to understand such complex relationships in a more practical fashion, logistic regression was conducted to better understand increased likelihoods of simple pass versus fail outcomes. A variety of predictors were considered in relation to pass versus fail as a dichotomous variable.

Logistic regressions

APS as a predictor of likelihood pass/fail.

Since logistic regression does not assume normal distribution in continuous predictor variables (Burns & Burns, 2009), the non-transformed APS variable was utilised for an accurate result in terms of specific increases in units. The results of the analysis for the 2010 intake produced a significant model (χ^2=115.509, p<.001) indicating a significant difference after the introduction of the predictor variable. Each unit increase in APS (i.e. each point of score) was associated with an increase of 1.081 (8.1%) in likelihood of passing or failing which, despite being statistically significant (W=108.633, p<.001) does not seem particularly impressive on a practical level. In the 2011 intake, a similarly significant model was produced (χ^2=87.216, p<.001). The result observed was a likely increase of 1.063 (6.3%) (W=79.292, p<.001) being associated with every one point increase in APS.

Specific PIBSpEEx scales as predictors of likelihood of pass/fail.

The results of the logistic regression models as per PIBSpEEx scale are presented in the following table.

Table 14: Logistic regression analysis utilising the three strongest PIBSpEEx scales in separate models

Year of Intake	***Scale***	***χ^2***	***P***	***Wald***	***P***	***Exp(B)***	***% increased likelihood to pass***
2010	Observance	17.958	.000	17.815	.013	1.155	15.0
	Insight	23.488	.012	23.149	.064	1.112	11.2
2011	Observance	38.528	.000	38.033	.000	1.225	22.5
	Insight	25.599	.022	24.098	.138	1.103	10.3

The results indicate that increases in the Observance scale produce a higher likelihood of passing than increases in the Insight scale. While examination of the PIBSpEEx Total scale demonstrated a 3.2% (2010) and 3.5% (2011) increase in likelihood to pass with each unit increase, the individual scales Observance and Insight seem to function somewhat better. In neither intake did the Insight scale achieve statistical significance (p>.05) as a predictor. Potentially, for practical purposes, the PIBSpEEx scale Observance may be more impressive than APS if non-normal distributions are considered, as is the case when range restrictions are unavoidable. It is possible that the simplification of the average mark variable into a binary variable reduced the effects of outliers, altering the predictive power of the PIBSpEEx scales.

DISCUSSION

Although cognitive assessments have been strongly correlated to schooling success in the past, primarily in developed countries (Neisser, 1997), it is worth noting that wide variation exists in type of cognitive assessment used and the underlying measurable skills (Anastasi & Urbina, 1997). It has previously been suggested that cognitive skills may develop only in specific contexts and their effects on education may be masked by differences in socio-economic status, quality of schooling and other factors (Wagner, 1978). However, certain skills may be 'released' by appropriate education, potentially providing a conceptual link between underlying cognitive ability and its ability to predict educational outcomes. For example, improvement in academic results following study skills improvement has been linked to increased meta-cognitive skills and problem solving styles (Villares, Frain, Brigman, Webb, & Peluso, 2012).

Prior to discussion, a number of barriers to full interpretation of the results of this study should be discussed. Firstly, cognitive skills development and expression is influenced by a variety of factors. Although these are global factors, more unique South African factors may contribute to incongruence with international findings. These factors include large cohorts of previously disadvantaged students from low socio-economic status backgrounds, differing perspectives regarding the impact of certain skills on the likelihood to fail and a potentially poor grasp of the English language (not explored here). In this case, although correlations and models achieved statistical significance, the effect sizes of the results were somewhat lower than those seen in similar international studies. This may be partially due to the pre-selection of the majority of sample within the institution's requirements along with the lack of PIBSpEEx data for a large number of admitted students, resulting in the necessity to impute missing data. Imputed data is well known to increase sampling variability, thereby producing lower effect sizes than if a full data set had be utilised (von Hippel, 2012). As a result, should a full data set have been present, it is possible that the statistical significance evidenced may have been accompanied by stronger effect sizes. This would have provided a more conclusive feel to the findings. Although it is not possible to say whether the lower predictive power and effect sizes evidenced here were due to range restriction, imputation procedures or effect sizes, it does appear that the instruments may have some real world significance as part of a predictive model.

Since the PIBSpEEx purports to measure underlying skill sets, free of schooling, a logical path of enquiry leads to the question of what cognitive constructs are important for secondary and tertiary study but are not necessarily formally examinable in terms of achievement outcomes. Since the Observance and Insight scales appear to be better predictors, investigation of this relationship should almost certainly begin there. As indicated previously, both these scales appear to deal with the capacity to draw conclusions from detailed, complex observation as well as tapping into logical reasoning and abstract conceptualisation skills. Unlike other scales, the Observance scale does not rely heavily on English language ability since no unusual or out of context language was utilised. Therefore, this scale is likely to measure learning potential in terms of the ability to identify new processes, syntheses and solutions rather than through skills reliant upon English language abilities.

It can be reasonably hypothesised that cognitive processes such as attention to detail, logical reasoning, inference of missing information and abstraction through focused attention are important for tertiary study. International studies have noted similar relationships utilising a variety of cognitive and reasoning assessments, particularly involving reasoning utilising some form of symbol system in non-verbal assessments (Lohman, 2005). The PIBSpEEx, like other cognitive assessments, purports to utilise the ability to grasp new skills and concepts (Erasmus, 2004). The focus of most cognitive assessments is on problem solving and reasoning to better understand potential for academic success, amongst other areas (Matarazzo, 1972; Sternberg & Pretz, 2005). The value of the Observance and Insight scales as predictors seems to lie in problem solving ability, reasoning skills and concept formations. In the case of the Insight scale, knowledge and comprehension of semantics does not appear as prominent as in the Mental Alertness scale or, indeed, the Calculations scale. Since the Insight scale primarily consists of reasoning utilising deduction, inferences, reconstruction of words and letters and in-depth interpretation of the consequences of reversals and re-arrangements, it appears that these are more important skills in predicting academic success.

Speed and time limit considerations are important in understanding the predictive capacity of the Observance and Insight scales. General observation of the testing processes indicated that students were able to finish all questions on these two scales well within the time limit. Studies on the Scholastic Aptitude Test, utilised in the United States of America for college entry, indicated that additional time was only advantageous to lower ability students and, even then, only up to a limited point. After this point, the length of testing without breaks made a lengthened time limit disadvantageous (Mandinach, Bridgeman, Cahalan-Laitusis, & Trapani, 2005). However, in an examination of a specific cognitive assessment, a Canadian study found that removal of time limits improved performance. This was most marked in students with poor understanding of the language in which the assessment was conducted (Mullane & McKelvie, 2001). Given that the majority of the students did not cite English as their home language, it is certainly possible that a combination of potentially poor English skills or forward and back translation during the assessment along with the strict time limits impacted the assessment results, particularly for the poorly operating scales (Mental Alertness, Calculations, etc.).

Grade 12 examinable material is fairly loaded on English language skills, with the exception of language specific papers. The PIBSpEEx purports to assess functionality in cognitive skill for a specific context and, therefore, instructions and tests are presented in English. This is due to the fact that the language of learning in tertiary education at this particular institution is exclusively English. From this alone, it is reasonable to conclude that the English language skills of the student have a bearing on later success. If language of instruction is used, throughout schooling, to construct cognitive concepts and skills, it is clear that lack of proficiency in such a language (or proficiency being acquired in a different language) will impact schooling results (Cantoni, 2007). However, the two concepts are interlinked, whereby improvement in literacy and reading is often tied to improvement of cognitive and meta-cognitive skills such as awareness, monitoring and regulating (Torgerson, 2007). It is almost impossible to disentangle the separate effects of English proficiency and cognitive ability. This problem is evidenced by difficulties in producing and understanding language and culture fair testing even when non-verbal assessments are used. The impact of English skills on the PIBSpEEx assessment and other facets was, in this study, relatively unknown since English proficiency was not directly measured. It is worth noting that requiring more complex understanding of vocabulary or meaning (e.g. Mental Alertness, word problems in Calculations) provided weaker correlations with both APS and average mark. This is a curious artefact since one would expect that if a scale were loaded in English and study was loaded in English a common denominator would provide a stronger relationship. From this it appears fairly clear that other factors are at play in success during studies although English language may be a limiting or overarching factor. In addition, it is possible that this factor contributed to the lower than the norm alpha values exhibited in this instrument.

CONCLUSION AND RECOMMENDATIONS

Based on the results of this study, it appears that the PIBSpEEx does contribute significantly to a base predictor of APS value in predicting average mark in tertiary study at a University of Technology. Despite limitations and relatively small effect sizes, it appears that cognitive assessments may be a valuable adjunct to the traditional Grade 12 results in selecting high potential students who are likely to succeed in National Diploma courses. However, this cognitive assessment should certainly not be used in isolation. Based on these findings, it is noteworthy that neither of these selection criteria performed as well as expected within the models utilised. As a result, the consideration of additional procedures such as interviews as well as identification of student needs, developmental areas and support requirements within the institutions may be essential. Further research into the cause of lower than expected predictive power of Grade 12 results as well as the potential predictive power of specific Grade 12 results may provide clarity on this issue, particularly as regards English language ability. It is not useful to promote elite selection in a country identified for the promotion of mass participation, although the necessity of some form of selection for students most likely to succeed should be attended to, particularly given the strong dependence on external funding for studies.

Given the challenges South Africa, and other developing countries, face in HEI's, selection is only one component of a larger scale focus in ensuring student success. In this case, this particular cognitive assessment demonstrated some value although it was insufficient to draw firm conclusions and further investigation is required. This is at odds with aforementioned literature indicating stronger statistically predictive values in cognitive assessments as part of selection criteria. Although promotion of mass participation was in reaction to low skills bases within the country, tertiary institutions are currently still facing challenges in producing the numbers of graduates required. In order to rectify this, a number of factors as outlined require consideration in order to effectively stream students and increase chances of success to benefit both the individual and the broader economy.

BIOGRAPHICAL NOTES

Ingrid Opperman is currently a PhD candidate focusing on the impact of alcohol on the different components of working memory. She completed her MA Research Psychology degree from the University of the Witwatersrand with distinction. She is also a registered psychometrist in independent practice and her research focuses primarily on cognitive psychometric testing.

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