

A preliminary inquiry on the association between pre-admission assessments and academic performance of first year dental technology students' within a South African university of technology

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ABSTRACT

Introduction

The use of selection, diagnostic, proficiency, placement, admission, manual dexterity and aptitude tests can reportedly predict students' academic success. Predictive admission procedures help to reduce dropout rates, improve academic performance, increase success rates, and selectively exclude applicants who are unlikely to be successful in the course. There is an absence of research, however, in this area of work in Dental Technology.

Aim

To examine the association between pre-admission assessments and Dental Technology students' academic performance in a South African University of Technology.

Design

A quantitative and cross-sectional study design was used.

Methods

The target populations were the 2018 and 2019 first-year Dental Technology students. Retrospective data extracted from academic records and programme files were statistically analysed to measure the correlations against students' academic performance.

Results

Despite there being no significant differences between pre-admission tests and students' academic performance, there were significant positive correlations between first-year university subjects.

Conclusions

There are indications of horizontal coherence between the discipline-specific subjects in the first-year Dental Technology curriculum.

Examining the association between pre-admission tests and students' academic results through to graduation, together with the horizontal and vertical alignments of all subjects in the undergraduate Dental Technology curriculum, can facilitate the learning pathways for students to succeed academically at universities.

Keywords

Manual dexterity tests, dental technology, curriculum coherence, cognitive abilities, psychomotor skills.

INTRODUCTION

The Council on Higher Education (CHE)¹ reported that despite a marked increase in student enrolment in South African higher education institutions in the last 15 years, students are still academically underprepared.

The CHE report critically highlighted that students need to be guided into the curriculum pathway "that will offer them the best opportunity to succeed".¹ Several scholars

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have therefore reiterated that entry-level assessments, such as diagnostic, proficient, placement and manual dexterity tests are required in the current educational climate.²⁻⁷

There are ongoing debates on the extent to which selection, diagnostic, proficiency, placement, admission, manual dexterity, and aptitude tests can predict student academic success.⁸⁻¹⁵ Arguably, predictive admission procedures can reduce dropout rates, improve academic performance, increase success rates, and selectively exclude applicants who are unlikely to be successful in the course.¹⁶⁻¹⁸

Furthermore, the aforementioned authors have unanimously indicated the value of predictive admission tests in providing rich information on the profile of students and informing curriculum design. The lack of these tests could therefore place students at risk of not completing their courses successfully. In turn, this has cost implications for both the student and the university.

Despite the burgeoning literature^{3-5,19-21} demonstrating the predictive value of manual dexterity tests, there is an absence of research on the predictive value of pre-admission tests for South African student dental technicians. Moreover, there is no consensus regarding the best predictive test or tests for admission into Dental Technology, which is a laboratory-based practice that requires students to have fine motor skills, hand-eye co-ordination and spatial perception.^{4,5}

From a higher education perspective, Vahed, McKenna and Singh elaborated that “the distinctive characteristics of Dental Technology is that it has both theoretical (or know-why) and practical (or know-how) knowledge”.²² Admission into Dental Technology training programmes at South African Universities of Technology (UoTs) are therefore based on a combination of cognitive and psychomotor tests.^{3,19,23} The aforementioned scholars have further argued the efficacy of manual dexterity tests as a screening instrument for the early indications on prospective students’ competencies, skills and knowledge. This enables academics to gain knowledge on students who will require additional academic development and support to succeed.

The Dental Technology programme at the Durban University of Technology (DUT), where this study was conducted, largely entails completing a set of theory and manual dexterity tests, which assess the “ability to use the hands in a skilful and coordinated way”.²⁴ Student interviews follow thereafter. Regardless of this comprehensive process, the 2011-2014 cohort throughput rates for the National Diploma in Dental Technology ranged between 10-50% (data provided under the auspices of the Siyaphumelela project by DUTs Department of Management Information, specifically via an email from K Parker, PhD (koo@dut.ac.za) in February 2020). These are below the faculty and the national norms.

In attempting to address the unacceptable throughput rates, selection and manual dexterity tests in Dental Technology were extensively re-vised in 2017 and 2018. It is against this background that predicting variables to

increase students’ academic success in the Dental Technology programme is believed to be imperative. This also critically responds to the recent South African Dental Technicians Council (SADTC) accreditation report, which recommended that the department “carry out retrospective research on the data of the last several years, to determine if there are any associations between test scores and subsequent success or otherwise”.²⁵

Using a retrospective and descriptive cross-sectional study within a quantitative framework, the aim of this study was to examine the association between first-year Dental Technology students’ academic results and various pre-admission measures. The objectives of this retrospective study were to:

1. Determine the relationship between biographical variables (i.e. gender, age, and home language) with students’ academic performance in selected first-year Dental Technology subjects.
2. Correlate school performance of individual subjects (i.e. Mathematics, Physical Science and English) with students’ academic performance in selected first-year Dental Technology subjects.
3. Determine the predictive value of Dental Technology Manual Dexterity Tests (DTMDT) with students’ academic performance in selected first-year Dental Technology subjects.
4. Determine the predictive value of the Standardised Assessment Test for Selection and Placement (SATAP) with students’ academic performance in selected first-year Dental Technology subjects. It should be noted that SATAP aims to identify students who might be at risk of under-performing and who require appropriate institutional support and/or interventions, such as intensive tutorials.²

It is envisaged that the retrospective data will provide significant prospective interventions such as using the results to improve the criteria and design of future pre- and post-admission processes. This could lead to the early identification of students who are at risk of failing. Furthermore, the results could provide early insights on students’ intellectual and academic profiles, which according to Scholtz and Allen-Ile “act as a basis for curriculum design”.²

METHODOLOGY

Study design and sampling

A post-positivism (or logical empiricism) paradigm within a quantitative and descriptive cross-sectional study design was used. The purpose of cross-sectional studies is to ascertain the “prevalence of a phenomenon, situation, problem, attitude or issue, by taking a cross-section of the population”.²⁶

Post-positivism is knowledge that is produced through testing proposals based on precise observation and measurement that is verifiable. Personal biases and prejudices of the researcher and participants are reduced, as objectivity is achieved by using multiple measures and observations to gain a clearer understanding of what is happening in reality.²⁷

Generally, there are two entry routes into the Dental Technology programme: namely, through the mainstream programme and through the extended curriculum programme (ECP). The minimum time for completion of the National Diploma qualification is three years for mainstream students and four years for ECP, as their first year of study extends over two years.

The total sample population consisted of the 2018 (n=46) and 2019 (n=26) registered first year Dental Technology students at DUT. In 2018, there were 25 mainstream and 21 ECP students whereas in 2019 there were 16 mainstream and 10 ECP students.

Data collection and analysis

The following data were retrospectively extracted from academic records and programme files located in the Dental Sciences department at DUT.

Independent variables

1. The 2017 and 2018 Grade 12 school-leaving results for the subjects are outlined in **Table 1**.

Although subject to some debate in the literature,^{28,29} the predictive power of school-leaving results as a measure of students succeeding academically in universities continues to be used.

2. Students' scores from their portfolio of work, which comprised of:
 - 2.1. A biographical questionnaire that comprised of five open-ended questions. Questions 1 - 4, which centred on health and recreational activities, are single items with responses averaging 1-2 lines of text. Question 5 however, has 12 sub-sections (i.e. 5.1 to 5.12) with responses averaging 3-5 lines of text. These questions focussed on parents' occupation, describing the work of a dental technician, and personal attributes in terms of strengths and areas of development.
 - 2.2 A sketch of a tooth.
 - 2.3 A photograph of a 'Coca-Cola, tomato sauce, or spice' bottle carved from a Sunlight® soap bar. Corroborating with the finding of Oweis, Ereifej and Abu Eid³⁰ and Nayak, Sahni, Singhvi et al's.³¹, the sketch and carving are used to create an early awareness for students of the kinds of psycho-

motor skills required in dental technology undergraduate programmes. According to Segura, Halabi and Navarro²⁴ "psychomotor skills are involved in procedures that are required to co-ordinate sensorial information with muscular response, as well as hand-eye synchronisation with hand and feet muscles motion, using a variety of dental instruments."

3. The DTMDT scores for four sections, namely, Drawing, Tooth Carving, Stone Block and Essay. Two independent Dental Technology examiners assessed each section using 5-point Likert Scale rubrics from five (excellent) to one (poor). The mean of both examiners' scores provided the final score per section. Essentially, these sections tested students' visual-spatial skills, ability to work with their hands, listening, communication, and the ability to follow instructions.
4. The SATAP results for Maths A, Maths B, Science and Academic Literacy.

Dependent variables

5. The 2018 and 2019 results for Tooth Morphology (TMOR 101 - focuses on cognitive and psychomotor skills), Oral Anatomy (OANA 101 - centres on cognitive abilities), and Applied Dental Technology (APDT 101 - tests psychomotor skills). A critical point is that student throughput rates for the above subjects continues to be low and therefore these subjects are identified as "at risk" at both faculty and university levels (as per email communication from K Parker in February 2019).

Following the collection of the various predictors or independent variables (biological profile, Grade 12 results, DTMDT and SATAP) and outcome measures or dependent variables (students' academic results for TMOR 101; OANA 101; and APDT 101), data was statistically analysed (SPSS® Version 26.0). Descriptive measures included the use of frequency and cross tabulation tables. Inferential statistics, which determines the differences and/or relationships between the variables, was conducted using Analysis of Variance (ANOVA), as the numerical data were normally distributed. Multiple Regression analyses and Pearson's correlation tests were used to measure the relationship between pre-admission variables and first-year university results. Results were considered significant for $p < 0.05$. A measure of reliability was performed using the mean total inter-item correlation (mean $r = 0.55$).

Table 1. School leaving subjects.

National Senior Certificate (NSC) Requirements		Senior Certificate (SC) Requirements		
Compulsory Subject	NSC Rating	Compulsory Subject	Higher Grade	Standard Grade
English (home) or English (1st additional)	3	English	E	C
Physical Sciences and/or Mathematics or Mathematics Literacy	3	Physical Science	E	B
	6			
And two 20 credit subjects (not more than one language)	3	Mathematics	E	B

Note:

- NSC rating of 3 and 6 is an achievement level between 40-49% and 70-79%, respectively.
- SC Grade B, C and E is an achievement level between 70-79%, 60-69% and 40-49%, respectively.

RESULTS

In determining the relationship between biographical variables and first-year academic performance in Dental Technology (Objective 1), **Table 2** summarises the descriptive statistics of the biographical data. There were no significant differences in the number of males and females and students from the mainstream programme and ECP.

Significant differences existed across other variables, particularly highlighting that the programme constituted a higher number of African students with English as a second language. Inevitably, more students completed the portfolio because it was a critical component of the application process. Nearly two-thirds of the students had selected Dental Technology as either their first or second pre-university choice of programme.

Generally, the mean scores of the selected first-year Dental Technology subjects for ECP students were higher than the mainstream students (**Table 3**). In particular, the mean scores of the mainstream male students who were younger than 20 years old and ECP female students older than 22 years were above 52% for Tooth Morphology (TMOR 101) and Oral Anatomy (OANA 101) subjects. Regardless of gender and age, both mainstream and ECP students mean scores for Applied Dental Technology (APDT101) are below 50%. These trends are also observed when using ANOVA Analyses (**Table 4**).

Multivariate tests were used to determine which pre-admission variable affected students' performances in Tooth Morphology, Oral Anatomy and Applied Dental Technology. Partial eta squared was deemed appropriate because the dependent variable was numerical and the independent variables were categorical.

Table 2. Descriptive statistics.

(n = 72)		Frequency	Percent	p-value
Gender	Male	32	44.4	0.346
	Female	40	55.6	
Ethnicity	African	60	83.3	< 0.001
	Indian	10	13.9	
Programme	White	2	2.8	0.239
	ECP	31	43.1	
English Language	Mainstream	41	56.9	0.002
	First	23	31.9	
School Leaving Results	Second	49	68.1	-
	Senior Certificate	72	100.0	
Portfolio	Yes	60	83.3	< 0.001
	No	12	16.7	
Pre-University Choice	First	23	31.9	0.010
	Second	24	33.3	
	Third	19	26.4	
	Fourth	6	8.3	

Note:

- NSC rating of 3 and 6 is an achievement level between 40-49% and 70-79%, respectively.
- SC Grade B, C and E is an achievement level between 70-79%, 60-69% and 40-49%, respectively.

As illustrated in **Table 4**, the blue highlights indicate that the pre-admission measures (independent variables) had a small effect on students' academic results for TMOR 101; OANA 101; and APDT 101 (dependent variables). Similarly, the green represents a medium effect and the yellow implies a large effect on the dependent variable by the independent variables.

Table 3. Comparison of gender and age against students' performances in selected first-year dental technology subjects.

Programme	Independent Variables	Dependent Variables: Dental Technology First-Year Subjects					
		Tooth Morphology TMOR 101					
		Age Group	Mean	Standard Deviation	Standard Error of Mean	95.0% Lower CL for Percentile 95	95.0% Upper CL for Percentile 95
ECP	Gender	< 20	-	-	-	-	-
		20 - 22	51.25	21.98	10.99	43.00	84.00
	Male	> 22	42.00	-	-	-	-
		< 20	-	-	-	-	-
	Female	20 - 22	49.89	16.36	5.45	58.00	69.00
		> 22	53.83	6.94	2.83	57.00	64.00
Mainstream	Gender	< 20	53.00	-	-	-	-
		20 - 22	41.00	20.53	7.76	51.00	69.00
	Male	> 22	34.25	15.48	7.74	36.00	55.00
		< 20	-	-	-	-	-
	Female	20 - 22	47.75	11.45	4.05	48.00	67.00
		> 22	45.67	22.59	13.04	48.00	67.00

Programme	Independent Variables	Applied Dental Technology APDT 101					
		Age Group	Mean	Standard Deviation	Standard Error of Mean	95.0% Lower CL for Percentile 95	95.0% Upper CL for Percentile 95
		ECP	Gender	< 20	-	-	-
20 - 22	48.00			-	-	-	-
Male	> 22		-	-	-	-	-
	< 20		-	-	-	-	-
Female	20 - 22		-	-	-	-	-
	> 22		-	-	-	-	-
Mainstream	Gender	< 20	46.00	-	-	-	-
		20 - 22	35.40	11.46	5.12	40.00	50.00
	Male	> 22	36.50	9.26	4.63	40.00	44.00
		< 20	-	-	-	-	-
	Female	20 - 22	48.86	5.46	2.06	51.00	57.00
		> 22	44.00	16.97	12.00	32.00	56.00

Programme	Independent Variables	Oral Anatomy OANA 101					
		Age Group	Mean	Standard Deviation	Standard Error of Mean	95.0% Lower CL for Percentile 95	95.0% Upper CL for Percentile 95
		ECP	Gender	< 20	-	-	-
20 - 22	36.00			8.66	5.00	31.00	46.00
Male	> 22		40.00	-	-	-	-
	< 20		-	-	-	-	-
Female	20 - 22		45.33	12.25	4.08	51.00	60.00
	> 22		54.83	9.06	3.70	61.00	66.00
Mainstream	Gender	< 20	56.00	-	-	-	-
		20 - 22	38.88	13.70	4.84	50.00	54.00
	Male	> 22	39.25	17.86	8.93	46.00	53.00
		< 20	-	-	-	-	-
	Female	20 - 22	48.89	6.85	2.28	51.00	62.00
		> 22	50.00	6.56	3.79	51.00	56.00

Correlation analyses, which measures “the closeness of the linear relationship between the defined variables” and defines the pattern of existing relationships known as regression analysis, revealed no significant correlation.³² In particular, no significant correlation existed between DTMDT scores (Objective 3) and SATAP results (Objective 4) against the students’ performances in the selected first-year Dental Technology subjects, respectively.

A noteworthy point, however, is that there is a significant positive correlation between university subjects. For instance, Mainstream students’ results showed a significant relationship between APDT 101 and TMOR 101 ($r=0.867, p<0.001$), OANA 101 and TMOR 101 ($r=0.687, p<0.001$), and OANA 101 and APDT 101 ($r=0.766, p<0.001$). Similarly, ECP students’ results showed a significant relationship between OANA101 and TMOR101 ($r=0.881; p<0.001$).

As illustrated in Table 5, the linear regression analyses performed for Objective Two revealed no significant non-zero coefficients ($p>0.05$) between the independent and dependant variables (TMOR 1010; APDT 1010; and OANA 101). Notably, all of the variance inflation factors (VIF) were less than the standard of 4, implying little multicollinearity.

There is only one significant p-value that is the influence of English Home Language on TMOR101 ($p=0.039$). The p-value, however, becomes non-significant (>0.05) after adjusting for mainstream and ECP groups. This indicates that the predictive power is not affected by the interplay of predictors. All unstandardised coefficients (B) are negative. Even though the p-values are not significant, it does indicate a trend that there is an inverse relationship between the dependent variable and the independent variables (school subjects).

DISCUSSION

This study sought to determine if there are any associations between Dental Technology students’ pre-admission scores and first-year students’ academic results. The section below discusses the results per research objective, recommends directions for future research and reports on the study’s limitations.

From Tables 3, 4 and 5 it can be inferred that the pre-admission measures are weak predictors for success in first-year Dental Technology subjects, particularly in terms of the skillset and prior knowledge needed to succeed in the programme. These results are consistent with the findings from previous studies.^{16,20,21,29}

Table 4. Multivariate analyses.

Factors	Dependent	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta-squared (η_p^2)
Gender	TMOR101	129.252	1	129.252	0.709	0.428	0.709
	APDT101	40.206	1	40.206	0.742	0.418	0.742
	OANA101	142.530	1	142.530	0.848	0.388	0.848
Age	TMOR101	209.158	2	104.579	0.574	0.588	0.574
	APDT101	61.486	2	30.743	0.567	0.591	0.567
	OANA101	444.272	2	222.136	1.322	0.326	1.322
English Home Language	TMOR101	0.308	1	0.308	0.002	0.968	0.002
	APDT101	0.906	1	0.906	0.017	0.901	0.017
	OANA101	39.611	1	39.611	0.236	0.642	0.236
Gender * Age	TMOR101	784.000	1	784.000	4.301	0.077	4.301
	APDT101	196.000	1	196.000	3.616	0.099	3.616
	OANA101	462.250	1	462.250	2.752	0.141	2.752
Gender * English Home Language	TMOR101	372.181	1	372.181	2.042	0.196	2.042
	APDT101	104.533	1	104.533	1.928	0.208	1.928
	OANA101	78.948	1	78.948	0.470	0.515	0.470

a). R Squared = .768 (Adjusted R Squared = .402)
 b). R Squared = .804 (Adjusted R Squared = .497)
 c). R Squared = .619 (Adjusted R Squared = .020)

Table 5. Linear regression analysis (Dependent Variable: TMOR 101)

Model	Independent Variables	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	(Constant)	251.516	79.734	-	3.154	0.016	-	-
	English Home	-1.756	0.691	-0.740	-2.542	0.039	0.790	1.267
	Maths	-1.627	0.789	-0.583	-2.061	0.078	0.837	1.195
	Physical Science	-0.240	0.732	-0.089	-0.328	0.753	0.911	1.098
2	(Constant)	250.634	86.266	-	2.905	0.027	-	-
	English Home	-1.709	0.826	-0.721	-2.070	0.084	0.642	1.556
	Maths	-1.603	0.870	-0.575	-1.843	0.115	0.801	1.248
	Physical Science	-0.257	0.801	-0.095	-0.322	0.759	0.885	1.130
	Mainstream/ECP	-1.545	11.847	-0.042	-0.130	0.900	0.759	1.318

Moreover, and from the analyses of gender and age against students' performances in selected first-year dental technology subjects (Table 3), it can be inferred that completing an additional year to the three-year formal mainstream programme enable ECP students to improve their performance in the 'know-why' theory and 'know-how' laboratory-based subjects. Notwithstanding this however, the mean score of <50% for APDT 101 supports the need for more rigorous DTMDT, which must be reviewed and revised continuously to ensure that pre-admission tests are developed to function for its intended purpose. Consistent with Poole, Catano and Cunningham, the robust monitoring between the theory and practical components of pre-admission tests facilitates more valid and reliable admission procedures to be developed.¹²

Concomitantly, it is recommended that socioeconomic and psychosocial variables be considered as previous predictive validity studies revealed that these variables positively correlate with academic performance.^{6,7}

In addition, it can be inferred that proficiency in Grade 12 school-leaving subjects such as Mathematics and Physical Science do not necessarily translate to success in first-year university subjects. This supports Stemler's¹⁵ argument that measures of achievement such as school-leaving results are an excellent starting point, however, these results tend to measure only a narrow range of student abilities. Rooy and Coetzee-Van Rooy²⁸ have therefore advised that students who are admitted into universities with school-leaving results below 65% will require additional support to succeed academically.

The higher number of African second language English students (Table 2) in the Dental Technology programme further suggests that concerted efforts are being made by DUT to address equity and redress, which are high on the South African higher education agendas.

Contrary to being an essential practice-specific pre-requisite for Dental Technology, the correlations between the DTMDT and SATAP results with first-year students' results in TMOR 101, OANA 101 and APDT 101 were weak. As argued by Schwibbe et al.,⁴ a factor possibly contributing to this is that psychomotor measures such as DTMDT do not predict performance in tests with theoretically rich content such as TMOR 101 and OANA 101.

This does not explain the weak correlation between DTMDT and APDT 101, however, both of which predominantly focus on psychomotor skills. Presumably, this could be a consequence of other contributing factors such as students' personal qualities, teaching and learning strategies used, and non-cognitive factors (student motivation and learning behaviour).

Analogous to Schwibbe et al.⁴ and Alhadlaq et al.,¹³ a significant limitation of this study is that it only assessed the relationship between pre-admission variables and selected first-year subjects. A recommendation therefore is that future research considers a longitudinal and mixed methods study to examine students' academic results through to graduation.

This is to include a deeper theorisation on the interactions between cognitive, non-cognitive and psychomotor abilities in the acquisition of laboratory-based techniques.

Even though pre-admission measures were not predictors of first-year Dental Technology students' academic performance, the positive correlations between the selected first-year subjects indicate that there is horizontal alignment or coherence between discipline-specific subjects within the first-year curriculum. Vahed, McKenna and Singh's²² study further supports this. They revealed that Tooth Morphology and Oral Anatomy provide the underpinning conceptual knowledge needed to produce and repair (applied knowledge) various dental appliances taught in Applied Dental Technology. For instance, the above authors elaborated that students acquire knowledge on the structural and functional anatomy of the muscles of mastication and facial expression, which is the intellectual field of the Oral Anatomy discipline. This knowledge underscores Applied Dental Technology, which is the field of laboratory-based practice.²²

Ultimately, the aim of the Dental Technology programme is to provide an appropriate balance in training students for the field of professional practice through APDT 101 while educating them on various disciplinary knowledge such as TMOR 101 and OANA 101. In view of the earlier recommendation to examine students' academic results from first year to graduation, a concurrent examination on the horizontal and vertical alignments of the subjects in the Dental Technology undergraduate curriculum will further serve to provide in-depth understanding of the extent to which students are learning the required knowledge and skills needed for industry. Herein is an area for further research, especially as Dental Technology programmes across South African UoTs are currently revising their undergraduate curricula.

CONCLUSION

Although the various pre-admission assessments used were not predictors of first-year Dental Technology students' academic performance, a salient finding is that there are indications of horizontal coherence between discipline-specific subjects within the first-year curriculum.

Examining the association between pre-admission tests and students' academic results through to graduation is critical, especially as Dental Technology programmes nationally are realigning their curricula according to the revised South African National Qualifications Framework. This combined with a closer analysis of the horizontal and vertical coherence of all subjects in the revised undergraduate Dental Technology curriculum can facilitate the learning pathways for students to succeed academically in universities.

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