Preadmission requirements as predictors of preclinical success for Dentistry students at the University of the Witwatersrand

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for Master of Science in Dentistry.

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DECLARATION

I **Dakalo Mulaudzi,** declare that this research report is my own, unaided work. It is submitted in partial fulfilment of the MSc Dent (Prosthodontics) degree. It has never been submitted before for any degree examination this or any other institution.

Signature: 

Date: May 2021

DEDICATION

I dedicate this research report to my parents Elisa and David Mulaudzi, my children Anzani and Thompho, my aunt Mercy for continued support. Last but not least, my siblings Thabelo, Rembuluwani and Rotondwa.

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NOMENCLATURE

ADA – American Dental Association

BDS – Bachelor of Dental Sciences

BIS – Business intelligence services

CDA – Canadian Dental Association

DAT – Dental Admission Test

GPA – Grade Point Average

HEI – Higher Education Institution

NSC – National Senior Certificate

NBT – National Benchmark Test

MDT – Manual Dexterity Test

OPDENT – Operative Dentistry

ORTHO - Orthodontics

PAT – Perceptual Ability Test

PROS – Prosthodontics

SA – South Africa

UP – University of Pretoria

Wits – The University of the Witwatersrand

1. CHAPTER ONE - INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

The Department of Basic Education (DBE) in South Africa (SA) governs all primary and secondary schools from both private and public education sectors (Education system South Africa, 2020). The basic education offer learners foundation to education, imparts basic life skills for lifelong learning, and also prepare them for further training opportunities towards their career of choice (DBE, 2020). A large population of learners attend public schools and there are inequalities between the two sectors, thus having a negative impact on the quality of education (Pather et al., 2017; Naicker, 2000; von Fintel, 2019).

The ability of learners to transition from Basic Education to Higher Education institutions (HEI) is a crucial step towards success in their tertiary education. There have been concerns regarding the preparedness of learners for university following high failure and attrition rates in universities (du Plessis and Gerber, 2012).

A cumulative national drop-out rate for undergraduate degree with a minimum duration of four years was reported in the cohort study for public higher education institutions from 2000-2009. The study reported a 22.5% drop-out rate by year two (2001), and the dropout rate was observed to increase as the years in the programme increased, wherein by the 10th year (2009), the dropout rate had increased to 38.3%. A decrease in the dropout rate was observed in an 8-year cohort study between 2010-2017, and it was reported to be 16.5% and 29.5% dropout rate at second and 8th year respectively (Department of higher education and training, 2020). Although there has been a decrease in the dropout rates over the years, HEI must facilitate the transition process with an ultimate goal of reducing attrition rate (Nel et al., 2009).

Various factors that play a role in the transition from basic education to higher education were identified, and these ranged from academic, cultural, and social factors with emotional factors included. These factors were found to be inter-dependent. Nel et al., (2009), therefore recommended that HEI should have a holistic approach in bridging the gap between the basic and HEI (Nel et al., 2009; van Rooij et al., 2018).

HEI have a responsibility of selecting suitable students for their chosen degree. The selection of students must be based on scientific evidence for it to be free of bias. The selection process must also be aimed at ensuring academic success of selected students (Coy et al., 2003). A study was conducted on the perceptions of students and lecturers on factors that influence success or failure for first year students at the University of Pretoria (UP) in South Africa (Fraser and Killen, 2003). Fifty-two (52) factors associated with success were identified. Appropriate choice of study programme, ability to implement theory into practice, self-discipline, student's interest, and ability to work independently were included in the list of factors. In addition, fifty-five (55) factors associated with failure were identified, and these included, inefficient time management, lack of ability to interpret theory into practical, as well as lack of interest and motivation. The importance of student satisfaction with the degree of choice, and their adjustment into the university environment were found to play a pivotal role in the prediction of success. These factors were reported to assist with students' intention to persist with the programme of study (van Rooij et al., 2018).

At the University of the Witwatersrand (Wits university), dentistry students are selected based on their pre-admission academic achievements, and 16 hours observation of clinical procedures by prospective students, in order to gain insight of this career path is required. The procedures observed must be performed by a qualified dental practitioner and certificate of attendance must be attached to the application documents before admission into the programme. The Bachelor of Dental Sciences (BDS) programme is described in the Guide for Undergraduate Applicants (2020) at Wits University, as a career that requires a combination of both hand motor skills and cognitive ability. For students to be selected into the BDS programme, the National Senior Certificate (NSC) and National Benchmark Tests (NBT) are a prerequisite. The main NSC subjects necessary for students to be considered for selection into the BDS programme are English, Mathematics, Physical Science and Life Science. Each subject must have a subminimum score of 5, which is equivalent to a 60% average score (Carroll and Schuster, 2015; Guide for undergraduate applicants, 2020). See ANNEXURE 1.

NBTs are an outcome of the National Benchmark Project that was commissioned by Universities in South Africa in 2005, and these were designed to assess the ability of

students to cope with the demands of university life. Based on the student performance, they are classified into basic, intermediate, and proficient levels, with the proficient level suggesting that a student should be able to cope with the demands of the regular programme. This assists higher education institutions with the placement of selected students to the correct curriculum route and curriculum development to best suit the student at their respective level (Le Roux and Sebolai, 2016).

The students are assessed in three core domains. See ANNEXURE 2. The information gathered from NBTs is used as an additional tool during the selection and placement process of students in their appropriate career path (Cliff, 2015; Du Plessis and Gerber, 2012).

NSC and NBT tools assess cognitive ability. There has been consensus amongst health professions that the student selection process should incorporate academic achievement and non-cognitive abilities (Salvatori, 2001). This may assist in enhancing students' learning experience during their training (Divaris et al., 2008) and improve their success rate while reducing attrition (van Rooij et al., 2018).

The BDS 1 programme includes two pre-clinical practical courses, namely, Prosthodontics (PROS) and Operative Dentistry (OPDENT) (Wits Prosthodontics Study Guide, 2019; Wits Operative Dentistry I and II study guide, 2019). These courses focus on training students to attain practical skills in preparation for clinical training commencing in the third year of study. In these courses, manual dexterity, psychomotor and visual skills, perceptual ability, and depth perception are enhanced. Possessing these non-cognitive skills is fundamental for students to be able to cope with the demands of these courses (Gray and Deem, 2002).

Each year, Wits University receives a large number of applicants from different educational backgrounds. Selection of suitable candidates must identify the level of both cognitive and non-cognitive skills for a prospective students (Lynch et al., 2006). The current admission criteria used for the BDS programme at the University of the Witwatersrand is devoid of an assessment of non-cognitive skills. The aim of this study was to assess the predictive capacity of pre-admission achievements on the students'

performance in Prosthodontics and Operative Dentistry pre-clinical techniques courses.

1.2. Literature review

There is a general assumption that matriculation results that are achieved at an above-average score guarantee success at university regardless of the degree of choice (Fraser and Killen 2003). A five-year cohort study by the Department of Education that commenced in the year 2000, reported that by the end of 2004 only 30% of the total first-time entering students had graduated and that 56% had left their original institutions. Only 14% remained in the system within this period (Scott et al., 2007).

The reasons reported for this overwhelming withdrawal, switch to different institutions and career changes varied from possible lack of interest, unrealistic expectations of the students, to the significant gap between high school & university education (Fraser and Killen, 2003; Nel et al., 2009). These factors highlighted the need for HEI to bridge the gap between themselves and basic education by using more predictive and relevant admission criteria. Various pre-admission criteria have been reported in the literature worldwide:

In (2004) in the United Kingdom (UK), Schwartz, together with the Admission to Higher Education Steering Group was assigned to review admission criteria to HEI, and to identify factors that constitute a fair admission process into higher education institutions. Several factors were reported to characterise the concept of fair admission and these were as follows.

- Selection criteria must assess both pre-admission academic achievements and potential of students using non cognitive assessments of relevant skills and interviews.
- Selection process must be transparent and free of bias.
- Assessment methods used must be reliable and valid.
- Professionalism of selection committee members is encouraged.

McCaig et al., (2008) reviewed how Schwartz principles were implemented in Higher education institutions in the UK, and the changes that occurred in the admission process to support those principles. They reported that some of the principles such as transparency, training of staff and continuing professional development and professionalism were adopted by higher education institutions. Many institutions

however reported that their admission process was not mainly influenced by the Schwartz principles. The practice and policies were, however, in fulfilment of these principles.

The admission criteria into dentistry programmes in the UK has been mainly based on pre-admission academic achievements and structured interviews that assess non-cognitive skills such as the ability of students to communicate, and to display a sense of professionalism among other factors. These assessments have been reported to have a positive impact on the students' performance in dental schools (Lynch et al., 2006).

A health professions literature review conducted in Canada examined evidence to support the use of various selection tools that include pre-admission academic performance, aptitude tests and interviews. Pre-admission academic performance was reported to be a good predictor to assess applicants' cognitive ability, rendering it a good predictor of academic success. The relationship between pre-admission academic performance and clinical performance was however not clear. It was, therefore, suggested that other non-cognitive variables such as aptitude tests, interviews, written submissions, and letters of references be taken into consideration, as they have been shown to contribute to both clinical and academic performance (Salvatori, 2001; Steele, 2011).

Novack and Turgeon, (2020), conducted a retrospective study at the University of Montreal, that was aimed at determining the predictive capacity of perceptual ability test (PAT) and manual dexterity test (MDT) on the success of students in dental school. The students' scores in PAT and MDT were compared with that of the pre-clinical and clinical classes. The results of the study showed strongest relationship between PAT and MDT with pre-clinical techniques courses, rendering them a greater predictive capacity. They, therefore, recommended that their use as an admission criteria may be beneficial to the students.

Gray and Deem, (2002), utilised Ackerman's theory of ability determinants of skilled performance to predict students' performance in pre-clinical techniques courses. The theory refers to individual differences in task performances during skills acquisition. It

specifies that under conditions such as tasks requiring attentional efforts, the correlations with intellectual ability remain stable; however, abilities associated with task performance are dependent on the stage of learning at which skill acquisition occurred. A decline in correlation between general intelligence and individual differences in task performance may occur with transitions from cognitive skill acquisition to the associative and autonomous stage of skill acquisition (Ackerman, 2005). This theory has been used in applied psychology to predict acquisition of complex skills. The PAT which is a sub-test of the above was hypothesised to be a valid cognitive determinant of spatial ability and could be used in selecting students into dentistry (Gray and Deem, 2002).

The results of the study confirmed the validity of Ackerman's theory in the pre-admission process. The PAT was reported to be a reliable predictor of students' performance in pre-clinical techniques courses. Although the PAT may assist in excluding candidates who have a greater probability of spending more time than required in the pre-clinical laboratory, repeat a year, or altogether not succeed in achieving the set goals and objectives of the techniques course. It was recommended that PAT should not be used as the only criterion to predict performance in pre-clinical techniques courses (Gray et al., 2002).

In another study by Schwibbe et al., (2016), the Ackerman's theory of ability determinants of skilled performance was also utilised to evaluate the influence of spatial and manual abilities on skills acquisition at Hamburg Dental School. They reported that spatial and manual abilities both influence the acquisition of dental skills in pre-clinical techniques courses. The authors recommended that inclusion of an assessment of manual and spatial abilities as pre-admission requirements could assist in placing students who may have a better chance of coping with the demand of the dental training programme.

In the United States of America and Canada, a standardised admission test called Dental Admission Test (DAT) was introduced following concerns about attrition rates as well as grade inflation which made it difficult to compare records of different schools and colleges (Allison et al., 2014). The DAT administered by the American Dental Association (ADA) and the Canadian Dental Association (CDA) included four

components: Survey of Natural Science, Quantitative Reasoning Test, Reading Comprehension and Perceptual Ability Test (Coy et al., 2003). Some differences between DAT and CDA admission tests were highlighted by Allison et al., 2014 and Peterson (1974), cited by Ranney et al., (2005). Canada also administers carving tests for measuring manual dexterity skills as an adjunct to the DAT.

The Canadian dental association dental admission test (CDA-DAT) measured both cognitive and non-cognitive abilities. Manual dexterity as a non-cognitive tool was reported to have weak to nil predictive validity (Allison et al., 2014). Ranney et al., (2005), reported that the predictive validity of non-cognitive tests was questionable due lack of reliable tests. They agreed with Gray and Deem, (2002) who further stated that the use of non-cognitive ability tests may be beneficial as a screening tool rather than a predictive tool, and that it may assist in reduction of attrition rate.

The use of wire bending as a predictor of practical performance in preclinical techniques courses was re-introduced in Hamburg Dental School between 2008-2010. The aim was to evaluate if wire bending tests can be used as an additional selection criteria tool for the dentistry programme. The results of the study showed an incremental validity of the wire bending test in assessing psychomotor skills, spatial ability, and dental skills, all of which were necessary qualities for coping in the pre-clinical techniques courses (Khothe et al., 2014). Other studies reported similar results (Gray et al., 2002; Schwibbe et al., 2016).

In 2015, Zawawi et al. conducted a study in the Faculty of Dentistry, King Abdulaziz University in Saudi Arabia to investigate the correlation between didactic and practical grades. They assessed the predictive capacity of students' didactic grades on their practical performance. The practical subjects of focus were: Dental Anatomy (DA), Operative Dentistry (OPDENT), Prosthodontics (PROS) and Orthodontics (ORTHO). All four subjects showed a correlation with didactic grades; however, a weak correlation was found between didactic grades and practical scores, indicating the need for an additional tool to assess practical ability.

In South Africa, a study was conducted at the University of Pretoria to determine the selection criteria for students who had the potential to cope with the demands of

dentistry training. The study was influenced by the concern raised by parents and students who claimed that “the criteria used lacked scientific evidence that students will complete the course in the prescribed time”. The four main areas that were recommended for the selection process are outlined in ANNEXURE 3. Interviews were carried out to identify the exact scope of practice of dentists. Participants were randomly selected from the University of Pretoria, the University of Glasgow as well as dentists working in private practice, public and academic hospitals. Ideal characteristics of a practising dentist were identified as physical attributes, cognitive potential, personality, and interpersonal skills. The study reported that the admission criteria into a dentistry program should include non-cognitive assessments such as visual and spatial ability, co-ordination, practical ability, and strength as a physical attribute. (Ebersohn and Maree, 2003).

The admission criteria at the University of Pretoria were reported to be based on cognitive abilities only and not taking into account other non-cognitive abilities which could assist students to cope with the practical demands of dentistry training and developing skills that would be transferred into real practice. The author, therefore, suggested that selection criteria must incorporate cognitive and non-cognitive abilities (Ebersohn and Maree, 2003).

Currently selection criteria in South African dental schools is based mainly on pre-admission academic achievements. Although practical skills can develop to a degree throughout the period of training in the dentistry programme, possessing non cognitive attributes prior to starting the programme may provide an advantage to the students, such that the time spent in preclinical techniques laboratories is not lengthened and the standard is raised. There is furthermore no study that has been reported that assessed pre-admission requirements as predictors of pre-clinical techniques performance in South Africa. Therefore, this study aims to assess the predictive ability of the current admission requirements.

2. CHAPTER TWO - AIMS AND OBJECTIVES

2.1. Aims

2.1.1. To review students' pre-admission scores and their final results in pre-clinical techniques courses in Operative Dentistry and Prosthodontics

2.1.2. To evaluate if there is any relationship between the pre-admission results for NSC (Maths, Life Science, English, and Physical Science) and NBT (Academic Literacy, Quantitative Literacy, and Maths), with pre-clinical techniques scores in operative dentistry and prosthodontics for first-year dental students at the University of the Witwatersrand.

2.2. Objectives

- To assess the relationship between NSC scores with the year mark for first year dentistry students in Operative Dentistry and Prosthodontics.
- To assess the relationship between NBT scores with the year mark for first year dentistry students in Operative Dentistry and Prosthodontics.

3. CHAPTER THREE - MATERIALS AND METHODS

3.1. Materials and methods

The study was conducted at the School of Oral Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. This was a retrospective study focusing on a nine-year cohort of BDS 1 students who were enrolled for the pre-clinical techniques courses for the first time from 2010-2018. The number of students for each year was as follows; 2010 = 38, 2011 = 15, 2012 = 27, 2013 = 30, 2014 = 50, 2015 = 11, 2016 = 37, 2017 = 29, 2018 = 32. The total number of students included in the sample size was 269. The data was acquired from Wits Business Intelligence Services (BIS). For each student, the following data were recorded:

1. NBT core domain scores for academic literacy, quantitative literacy, and mathematics (percentage out of 100%).
2. NSC subject scores for English, maths, physical science, and life science (percentage out of 100%).
3. Prosthodontics pre-clinical techniques year mark (percentage out of 100%).
4. Operative dentistry pre-clinical techniques year mark (percentage out of 100%).

3.2. Inclusion and exclusion criteria.

- Students who were doing BDS 1 for the first time in each year were included.
- Students who de-registered or dropped out in each year were excluded.
- All students who were enrolled without NBT results were excluded.

3.3. Sample size

The sample size was estimated using G*Power 3.1.9.7. A minimum of 133 students were required to perform multiple linear regressions with 10 predictive variables. The parameters used to calculate the sample size were effect size = 0.1, margin of error = 0.05 and 95% power.

3.4. Data analysis

A test for normal distribution was conducted on continuous variables. Based on the normality test results, the following statistical tests were used to analyse the data:

Descriptive statistics of mean and standard deviation were used to summarise normally distributed continuous variables (Quantitative Literacy, Mathematics and English). The median and interquartile were used to summarise skewed continuous variables (Prosthodontics, Operative Dentistry, Academic Literacy, Life Sciences, Physical Sciences and Mathematics NSC).

Study variables were summarised by the mean and standard deviation. Skewed continuous data were summarized using median and interquartile range. Frequency and percentage were used to analyse categorical data. The Spearman correlation coefficient was used to determine the correlation between pre-clinical subjects (Prosthodontics and Operative Dentistry) and NBTs, as well as NSC subjects. Continuous variables and linear regression were used to determine the predictors of the Prosthodontics and the Operative Dentistry scores. Univariate and multivariate linear regression was used to determine the relationship between pre-clinical subjects and pre-admission required subjects. Level of significance was set at p-value less than 0.05.

3.5. Limitations

The study was conducted on cohorts of students at Wits University, Johannesburg, South Africa. The application of the results obtained is therefore limited to the above-mentioned university.

4. CHAPTER 4. RESULTS

4.1. Population size

The student population included in the study was 269 first entering BDS 1 students at Wits University obtained from nine cohorts between 2010 and 2018. All these students had both NBT and NSC results as preadmission requirements. The distribution of students differed among the years with highest number in 2014 (50) and the lowest number in 2015 (11) (Figure 1).

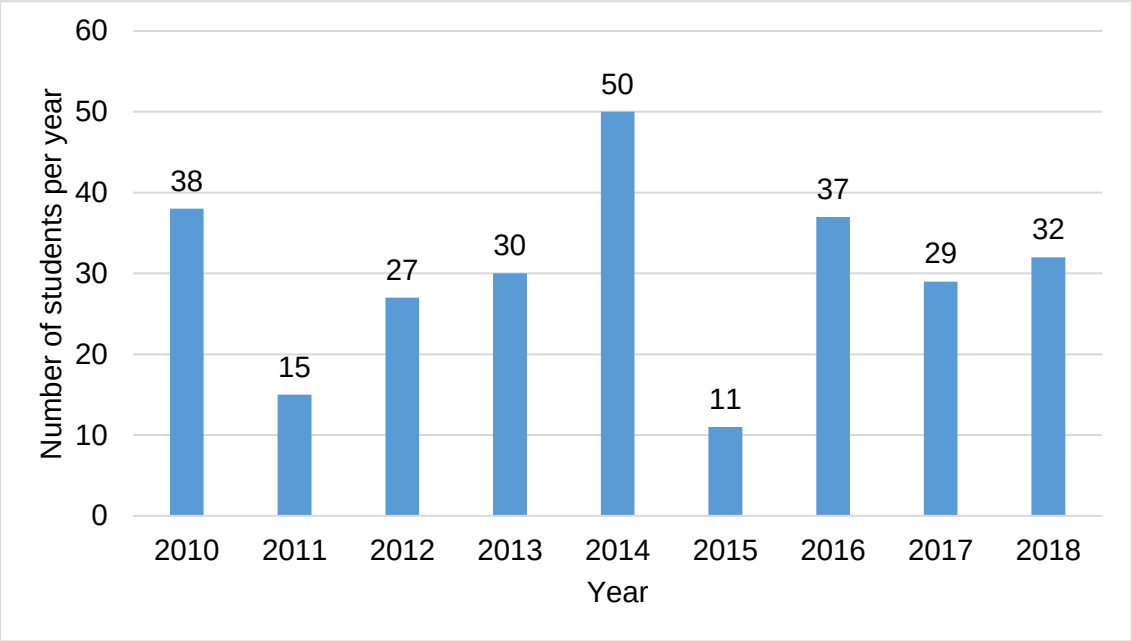

Figure 1: Number of BDS 1 Students enrolled from 2010 - 2018 (N=269)

4.2. Analysis of the Sample

The Shapiro-Wilk test for normality was conducted on the continuous variables to determine the normality of distribution (Table 1). Variables with p-value < 0.05 are skewed.

Table 1: Test for Normality

	Shapiro-Wilk	
	Statistic	Sig.
Pre-clinical dentistry subjects		
Prosthodontics	0.932	0.00
Operative Dentistry	0.826	0.00
NBT		
Quantitative Literacy	0.989	0.20
Academic Literacy	0.965	0.00
Mathematics	0.987	0.12
NSC		
English	0.995	0.82
Life Sciences	0.976	0.00
Mathematics	0.940	0.00
Physical Sciences	0.965	0.00

Based on the test for normality results, non-parametric tests of median and interquartile range were used to summarise the variables that are not normally distributed (p=<0.05) as follows: Prosthodontics, Operative Dentistry, Academic Literacy, Life Sciences, Mathematics NSC and Physical Sciences. Parametric tests of mean and standard deviation were used to summarise the variables that are normally distributed (p>0.05) Mathematics NBT, Quantitative Literacy and English. For graphical representation of the normal and skewed data distraction of the variable, see ANNEXURE 4.

4.3. Analysis of the Relationships between the variables

4.3.1. NSC, Prosthodontics and Operative Dentistry preclinical courses

First year dentistry student's NSC results were assessed for each cohort. In 2015, the scores were the highest for Life Sciences with an average of 89% (75-92) followed by Mathematics at 88% (73-89). The average scores for English and Physical Sciences were similar at a score of 77% (Table 2).

Table 2: Average NSC scores per cohort

Year	English, Mean (SD)	Mathematics, Median (Interquartile range)	Life Sciences, Median (Interquartile range)	Physical Sciences, Median (Interquartile range)
2010	79.85(4.29)	87(80.5-90)	82(80-86)	71(65.5-76)
2011	75.79(8.15)	82(79-87.25)	86(76.25-91.75)	83(73-89.75)
2012	77.45(6.68)	83(77.5-86.75)	84(81-86)	78.5(69.5-84.75)
2013	78.14(6.89)	83(74-86)	82(78-85.50)	78(68.5-89.4)
2014	78.89(8.00)	82(75.5-87.5)	83(79.5-88)	79(70-85.5)
2015	78.57(11.03)	88(73-89)	89(75-92)	79(74-85)
2016	77.91(6.43)	86(75-91)	84(78.5-89)	82(72-88)
2017	76.68(7.56)	75(67.5-83)	78(74.75-86)	74(69.75-78.25)
2018	75.35(8.06)	79(71-83)	80(75-86)	81(71-86)
Average	77.75 (7.19)	83(74.75-88)	83(78-87)	77(70-85)

4.3.2. The relationship between NSC, Operative Dentistry and Prosthodontics preclinical courses

Table 3 shows average scores obtained for Prosthodontics and Operative Dentistry preclinical courses per cohort. The highest average scores obtained in Prosthodontics were observed in 2014 and 2015 at 75%. The lowest score was observed between 2016 and 2018 at 60 % (60-65). For Operative Dentistry, the highest average score was 70(66-75) recorded in 2016 while the lowest average score was 60% recorded in all other years except 2013 and 2016.

Table 3: Prosthodontics and Operative Dentistry results per cohort

	Median (Interquartile)	
Year	**Prosthodontics**	**Operative Dentistry**
2010	65(60-75)	60(60-65)
2011	70(62.5-70)	60(60-65)
2012	65(60-70)	60(60-65)
2013	62(60-67.75)	64(61.5-70)
2014	75(65-80)	60(50-66.25)
2015	75(61-77)	60(60-71)
2016	60(60-65)	70(66-75)
2017	60(60-65)	60(57.75-65)
2018	60(56-63)	60(60-65)
Average	65(60-70)	64(60-67)

Spearman correlation coefficient was used to determine the correlation between NSC and the pre-clinical dentistry subjects (Table 4). The correlation coefficient is classified into weak (0-0.3), moderate (0.3-0.7) and strong (0.7-1). There was a significant positive weak correlation between Prosthodontics and the NSC subjects' i.e., Mathematics (rho=0.217, p=0.001) and Life Sciences (rho=0.187 p=0.006). There was no significant correlation between Operative Dentistry and the NSC subjects Physical Sciences, Life Sciences and English Language (p>0.05). There was a significant weak positive correlation between Operative Dentistry and Mathematics (rho=0.174, p=0.012).

Table 4: Correlation between NSC, Operative Dentistry and Prosthodontics

Spearman's rho	NSC	English	Mathematics	Life Sciences	Physical Sciences
Prosthodontics	Correlation Coefficient	0.086	0.217**	0.187**	0.114
	p-value	0.196	0.001	0.006	0.094
Operative Dentistry	Correlation Coefficient	0.08	0.174*	0.13	0.109
	p-value	0.248	0.012	0.064	0.121

Further analysis using linear regression (Table 5) showed that a one percent increase in Mathematics and Life Sciences would significantly increase the Prosthodontics score by 0.20 and 0.17, respectively. This implies that Mathematics and Life Sciences were significant predictors of Prosthodontics. A one percent increase in Mathematics, English, life science as well as physical science will increase operative dentistry scores by ol12, 0.07,0.056 and 0.086 respectively, although this is not significant. P-value>0.05.

Table 5: Univariate predictors of Prosthodontics and Operative Dentistry scores using the NSC scores.

	Prosthodontics			Operative Dentistry		
	B	**p-value**	**95CI (lower-upper)**	**B**	**p-value**	**95CI (lower–upper)**
Mathematics	0.20	0.003	0.071 - 0.332	0.12	0.087	-0.016 - 0.232
English	0.07	0.302	-0.087 - 0.279	0.07	0.315	-0.086 - 0.267
Life Sciences	0.17	0.013	0.051 - 0.415	0.056	0.426	-0.014 – 0.246
Physics Sciences	0.12	0.081	0.014 - 0.239	0.086	0.22	-0.045 - 0192

4.3.3. Average NBT results according to the cohorts.

The highest average NBT score recorded was in Academic Literacy at 71 % and the lowest in Mathematics at 58.64 % respectively (Table 6). NBT results were analysed, and the annual reports show that the average scores for Mathematics were highest at 67.03% in 2016 and lowest at 45.86% in 2010. Academic Literacy was highest at 73% in 2013 and 2014, and lowest at 63.5% in 2018. Quantitative Literacy was highest in 2014 at 69.06% and lowest in 2010 at 58.86%. (Table 6).

Table 6: Average NBT subject scores according to the year

	Quantitative Literacy, Mean (SD)	**Academic literacy, Median (Interquartile range)**	**Mathematics, Mean (SD)**
2010	58.86(8.09)	71(67-78)	45.86(12.01)
2011	65.93(11.36)	71(66-75)	52.8(8.82)
2012	66.11(12.89)	71(66-78)	54.48(14.59)
2013	65.63(10.11)	73(64.75-78.5)	55.43(13.38)
2014	69.06(10.95)	73(68-77)	63.36(14.93)
2015	67.18(12.38)	72(68-80)	62.36(16.53)
2016	66.27(12.31)	71(68-78.5)	67.03(16.99)
2017	59.14(12.20)	70(59-74)	55.14(16.55)
2018	62.78(13.61)	63.5(59-73.5)	55.42(13.80)
Total	65.22 (12.09)	71(64-77)	58.64 (15.55)

4.3.4. Relationship between Prosthodontics and Operative Dentistry preclinical courses with NBT subjects

The Spearman correlation coefficient test was used to determine correlations between first year pre-clinical dentistry courses and the NBT subject average marks (Table 7). The results showed that there were significant weak positive relationships between Prosthodontics scores and all the NBT marks. Operative Dentistry showed a positive weak significant correlation with only Academic Literacy (rs=0.139, *p-value < 0.05).

Table 7: Correlation between NBT, OPDENT and PROS average scores

Spearman's rho		**Quantitative Literacy**	**Academic Literacy**	**Mathematics**
Prosthodontics	Correlation Coefficient	0.198**	0.146*	0.134*
	p-value	0.003	0.027	0.043
	N	230	230	229
Operative Dentistry	Correlation Coefficient	0.018	0.139*	0.062
	p-value	0.791	0.044	0.377
	N	209	209	208

Further analysis using univariate linear regression was used to determine the NBT subjects' predictors for Prosthodontics and Operative Dentistry scores. (Table 8). The results showed that Quantitative Literacy mark is a significant predictor of prosthodontics score (p-value=0.007). A one percent increase in Quantitative Literacy score would increase Prosthodontics score by 0.19. None of the NBT subjects was a significant predictor of Operative Dentistry.

Table 8: Univariate linear regression to determine the predictors of Prosthodontics and Operative Dentistry

	Prosthodontics			**Operative Dentistry**		
	B	**p-value**	**95CI (lower- upper)**	**B**	**p-value**	**95CI (lower - upper)**
Quantitative literacy	0.19	0.007*	0.041 - 0.255	0.04	0.524	- 0.081 - 0.158
Academic literacy	0.13	0.056	-0.004 - 0.285	0.07	0.300	- 0.074 - 0.238
Maths	0.12	0.075	-0.008 - 0.16	0.08	0.248	- 0.039 - 0.149

4.3.5. Multiple linear regressions

Multivariate stepwise regression analysis was done to determine the NSC and NBT predictors of Prosthodontics adjusting for all the subjects. The results show that Mathematics (NSC) was a significant predictor of Prosthodontics score. A one percent increase in Mathematics score would increase the Prosthodontics score by 0.189 after adjusting for all the other NBT and NSC subjects, p-value = 0.01 with a confidence interval of 0.044 – 0.322 (Table 9).

Table 9: Model summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	Change Statistics				
					R^2 change	F Change	df1	df2	Sig. Change
1	.189a	0.04	0.03	9.76	0.04	6.78	1	183	0.01

	Beta	p-value	Lower	Upper
Maths NSC	0.189	0.01	0.044	0.322

Excluded variables.

Model		Beta In	T	Sig.	Partial correlation	Collinearity stats
						Tolerance
1	Quantitative literacy	.13b	1.737	0.084	0.128	0.911
	Academic literacy	.080b	1.102	0.272	0.081	0.991
	Maths NBT	-.039b	0.454	0.651	-0.034	0.712
	English	-.023b	0.305	0.761	-0.023	0.903
	Life science	.070b	0.830	0.408	-0.061	0.750
	Physical science	.029b	0.298	0.766	0.022	0.567
a. Dependent variable: prosthodontics						
b. Predictors in the model: (constant) maths NSC						

4.4. Summary of statistical tests

1. Descriptive statistics of mean and standard deviation was used to summarise normally distributed continuous variables (Quantitative Literacy, Mathematics and English).

2. The median and interquartile was used to summarise skewed continuous variables (Prosthodontics, Operative Dentistry, Academic Literacy, Life Sciences, Physical Sciences and Mathematics NSC). Frequency and percentage were used to analyse categorical data.

3. Spearman correlation coefficient (with the assumption that the continuous data is skewed) was used to determine the correlation between pre-clinical subjects (Prosthodontics and Operative Dentistry) and NBTs, as well as NSC subjects.

4. After the Spearman correlation coefficient was conducted, univariate linear regression was used to determine the individual subject predictors of the Prosthodontics and the Operative Dentistry scores.

5. The NSC subjects were then included in multivariate linear regression model to determine the pre-clinical subjects and pre-admission required subjects that are predictors of Prosthodontics and Operative Dentistry scores.

6. Level of significance was set at p-value less than 0.05.

5. CHAPTER FIVE – DISCUSSION

A review of first year dentistry students' pre-admission scores (NSC and NBTs) and final scores in pre-clinical techniques courses (Prosthodontics and Operative Dentistry) was carried out. The variables were correlated throughout the 9 cohorts of students between 2010- 2018. Within the study population of 269, the distribution of students within the cohorts differed with the largest group of students enrolled in 2014 totalling 50 and the smallest groups reported in 2011 at 15 and 2015 at 11, respectively. The small group reported could be as a result of a large group enrolled in the succeeding years (2010 at 38 and 2014 at 50).

Cohort selection process was informed by the years when curriculum changes were introduced. In the year 2010, Paediatrics and Restorative Dentistry, together with Prosthodontics pre-clinical techniques courses were introduced to the first year BDS programme at Wits University. Further amendments in the curriculum were made in 2013, during which Chemistry, Physics and Biology were completely removed as subjects in the first year of study. In 2014, The Paediatrics and Restorative Dentistry course was renamed Operative Dentistry without any changes to the curriculum content. This justified the inclusion of 2010-2013 results in the study. The logic behind early introduction of these techniques courses was to expose students to basic skills required in dentistry, in order to prepare them for the clinical environment where there will be treatment of patients.

The NSC results for the nine cohorts recorded revealed average scores for English, Mathematics, Life Sciences and Physical Sciences to be 77.8, 83, 83, and 77 % respectively. These results demonstrated that although the preadmission sub-minimum score as stipulated in the Wits undergraduate study guide is 60%, students with higher scores have a better chance to be selected from the pool of applicants for admission into the dentistry programme. This is attributed to the use of academic results as the only selection criterion currently used at Wits University.

The average scores for students' NBT results were recorded for Quantitative Literacy, Mathematics and Qualitative Literacy with Mathematics scores being the lowest. The students' performance was not as high as it was in the NSC examination results. In 2012, du Plessis and Gerber conducted a prospective study to explore which pre-admission results assist with the placement of students in HEI. The study was focused on the fields of sciences, information technology and accounting. Their pre-admission results in NSC and NBT were correlated with their first-year performance in core subjects of the fields above.

The NSC results showed a stronger relationship than the NBT results. Although there was a stronger relationship with NSC results when compared to NBT results, their role in complementing the NSC results cannot be ignored. This is supported by Mabizela and George (2020), who reported that when NBT results are equally weighted with NSC results, a stronger predictive capacity for student academic success of first year medical students was noted. Du Plessis and Gerber (2012) then recommended that NBT results be used as an adjunct to the NSC results, to assist universities to classify student as proficient or less proficient. The less proficient students would possibly require an extended programme to adjust well into the main programme. Although this study was not conducted in the clinical field, the main pre-admission subjects were similar to those required in dentistry programme.

The NSC variables were correlated with Prosthodontics and Operative Dentistry's first year results. Mathematics and Life Sciences were found to significantly predict student's success in Prosthodontics. A unit percentage increase in mathematics and life sciences was shown to significantly increase prosthodontics score by 0.20 and 0.17, respectively. No relationship was established between NSC subjects and success in Operative Dentistry pre-clinical techniques for first-year dentistry students.

The NSC Mathematics curriculum of Basic Education in South Africa teaches students to apply the principles of geometry to solid figures, three-dimensional and two-dimensional representations of shapes, perspective, as well as perception and comparison of shapes. These principles have been identified as the knowledge assumed to be in place for first year dentistry students as stipulated in the Wits Prosthodontics study guide of 2019. Possessing mathematics as a subject pre-

admission may assist students to cope with the demands of Prosthodontics in first year.

In the NSC's Life Science curriculum in South Africa, students are taught a level of academic and scientific literacy that enables them to read, talk, write, and think about biological processes, concepts, and investigations. This has also been identified as embedded knowledge for student in their first-year prosthodontics course (Wits Prosthodontics study guide 2019).

Relying on academic achievements as admission criteria for dentistry programme has been challenged in the literature. This came as a result of concerns raised regarding the validity of this admission criterion in predicting success in pre-clinical techniques courses which has practical ability component. Gray and Deem (2002) used Ackerman's theory of academic determinants of skilled performance where they recommended that there is a need for an additional admission tool that will assess non cognitive skills. Similar findings were reported by Schwibbe et al., (2016). Ebersohn and Maree, (2003), recommended that over and above cognitive ability, the use of non-cognitive ability such as physical attributes (e.g., practical ability), personality and interpersonal skills may assist in exclusion of students who may have difficulty coping with the demands of the dentistry programme.

Correlation of the average NBT results and Preclinical Prosthodontics scores for BDS 1 students demonstrated a significantly weak positive relationship that exist with all NBT subject results. Of all the variables in NBT, Quantitative Literacy was a significant predictor of Prosthodontics score with a p-value of 0.007. The results thus suggest that students who perform better in Quantitative Literacy have a greater chance of performing better in prosthodontics. NBT results however, were found not to be predictors of student success in operative dentistry pre-clinical techniques course for first-year students.

These results may be reflective of what the curriculum of NBT Quantitative Literacy entails. Griesel (2006) identified elements that makes up the definition of quantitative literacy. These include student's ability to manage the situations or solve problems in real context, their ability to read, interpret tables, graphs, and charts. The subject also

assesses student's ability to do simple calculations, logical reasoning, identify trends and patterns in different situations, as well as understand basic numerical concepts. Therefore, being not only a didactic course, but prosthodontics also requires a student to possess practical and visualisation skills over and above their cognitive ability. This is in alignment with the results reported in the study that Quantitative Literacy is a significant predictor of success in Prosthodontics.

NBT and NSC results play a role in the performance of students in the dentistry programme. The weak correlation found in this study however shows that there are other non-cognitive factors that play a role in the performance of first-year students in Prosthodontics and Operative Dentistry. These observations were also highlighted by Nel et al., (2009), who reported that admission requirements to dental school assessed by the Grade Point Average were weak predictors of academic performance in first year.

6. CHAPTER SIX – CONCLUSION

Within the limitations of this particular study, the results suggest that there are some variables in the pre-admission requirements at Wits University that statistically predict students' performance in pre-clinical Prosthodontics and Operative Dentistry techniques courses. The correlation between the various requirements and the pre-clinical courses is however weak, and not constant. In addition to cognitive ability, possessing certain non-cognitive skills maybe needed when learning these pre-clinical techniques courses. It is therefore proposed that pre-clinical performance might be linked to other factors which are not covered in this study.

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ANNEXURE ONE

The curriculum for each of the subject is different and is described in the curriculum assessment policy statement that was released by the department of basic education in South Africa, 2011.

Subject	Purpose and skills to be attained
Physical sciences	• Promotes knowledge and skills in scientific inquiry and problem solving. • Construction and application of scientific and technological knowledge. • An understanding of the nature of science and its relationships to technology, society, and the environment.
Life sciences	• knowledge of key biological concepts, processes, systems, and theories. • Ability to critically evaluate and debate scientific issues and processes. • An understanding of the ways in which humans have impacted negatively on the environment and organisms living in it. • Scientific skills and ways of thinking scientifically that enable them to see the flaws in pseudo-science in a level of academic and scientific literacy that enables them to read, talk about, write, and think about biological processes, concepts, and investigations. • A level of academic and scientific literacy that enables them to read, talk about, write, and think about biological processes, concepts, and investigations.
Mathematics	• Develop the correct use of Mathematics language. • Collect, analyse, and organise quantitative data to evaluate and critique results.

	• Use mathematical process skills to identify, investigate and solve problems creatively and critically. • Use spatial skills and properties of shapes and objects to identify, pose and solve problems creatively and critically.
English	• Most students in South Africa enrol for English as a first additional language, where they acquire skills to communicate accurately and appropriately taking into account audience, purpose, and context. • Use their Additional Language for academic learning across the curriculum. • Listen, speak, read/view and write/present the language with confidence and enjoyment. • Express and justify, orally and in writing, their own ideas, views, and emotions confidently in order to become independent and analytical thinkers. • Use their Additional Language to access and manage information for learning across the curriculum and in a wide range of other contexts. Information literacy is a vital skill in the 'information age' and forms the basis for • Lifelong learning; use their Additional Language as a means of critical and creative thinking: for expressing their opinions on • Ethical issues and values; for interacting critically with a wide range of texts; for challenging the perspectives,

ANNEXURE TWO

Below are the core domains and their objectives.

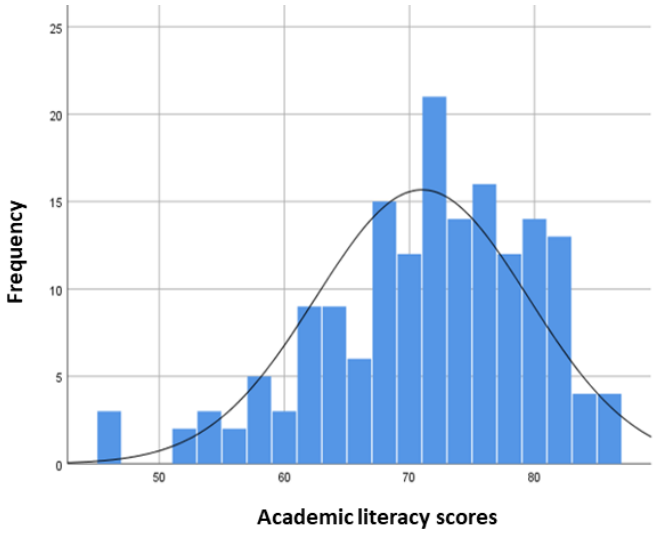
Core domains	Objectives
Academic literacy	Assesses student's capacity to cope successfully with the demands of academic study in the medium of instruction.
Quantitative literacy	Assess student's ability to manage situations or solve problems of quantitative nature in real contexts of relevant to higher education.
mathematics	Assess students' ability to grasp mathematical concepts, which form part of the NSC Mathematics curriculum.

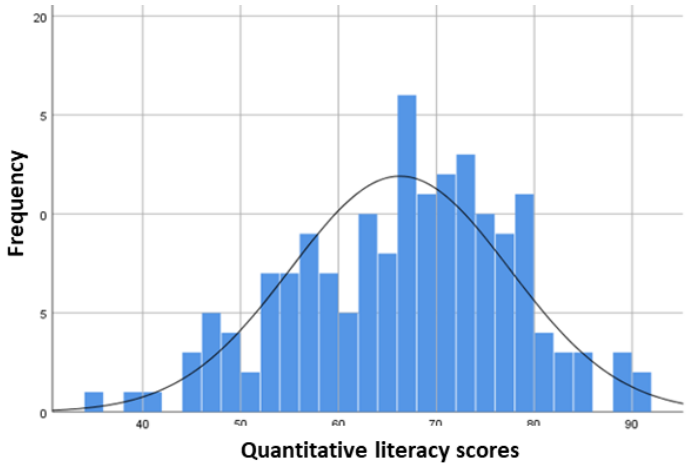
ANNEXURE THREE

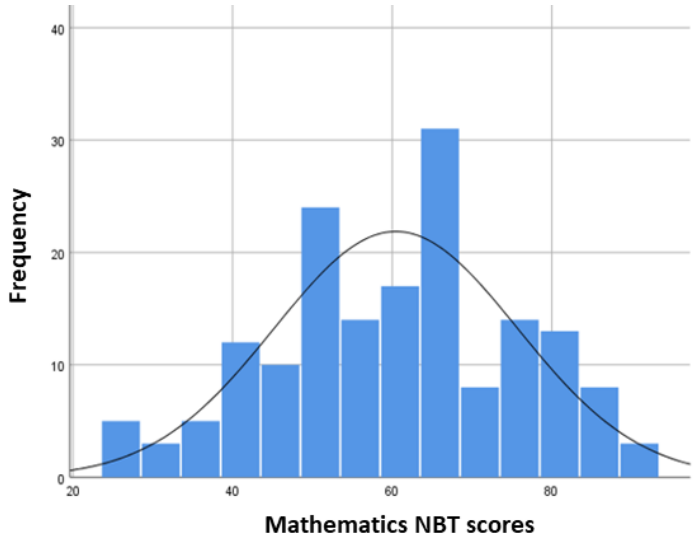
Recommended selection process - 4 phases (Ebersohn and Maree, 2003)

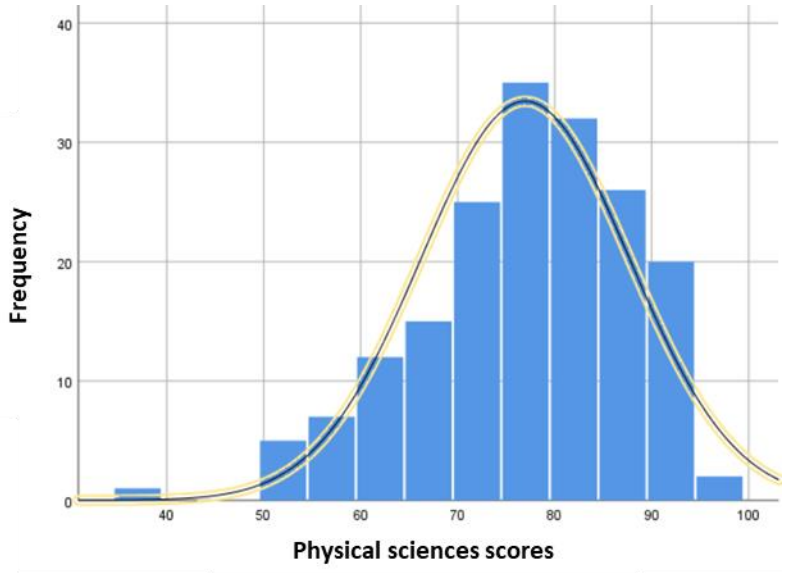
Phase	Format	Process
1	Application forms Biographical Questionnaires references	Sifting of candidates who meet minimum admission requirements.
2	Psychometric tests • • Aptitude • • Interest • • Personality • • Intelligence	Candidates with highest scores are provisionally selected on grounds of weighted credits for each criterion.
3	Interview Assessment of manual skills	Final selection- candidates are selected by a qualified panel.
4	Meaning and training	Support of certain candidates. Value added courses. Support programmes.

ANNEXURE FOUR





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100
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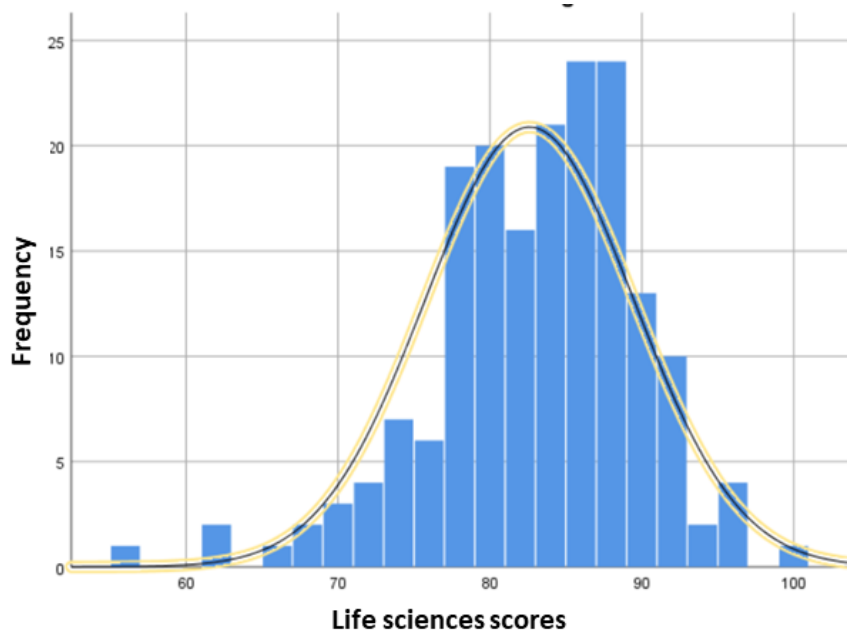
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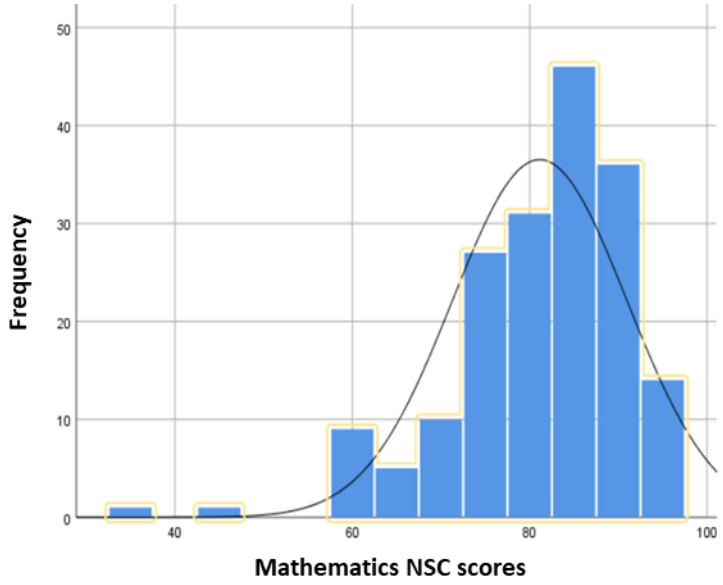
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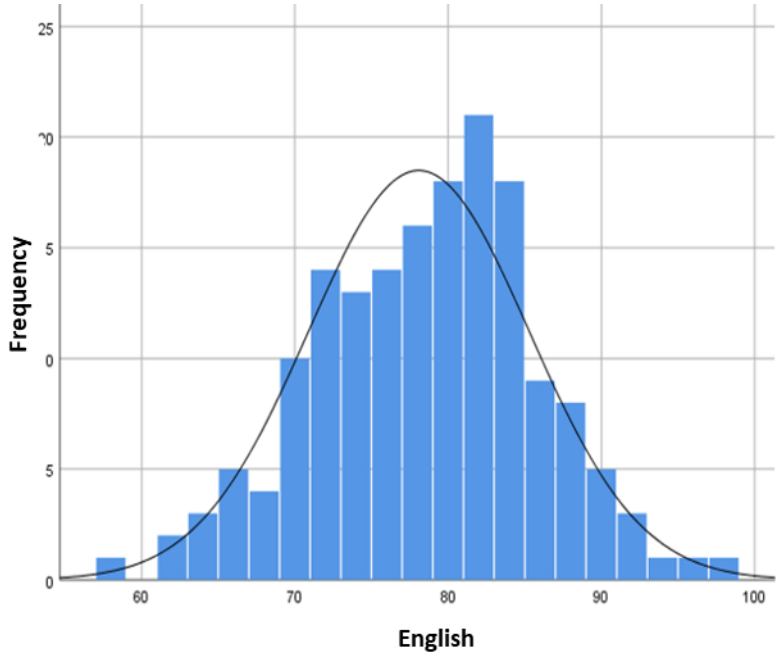
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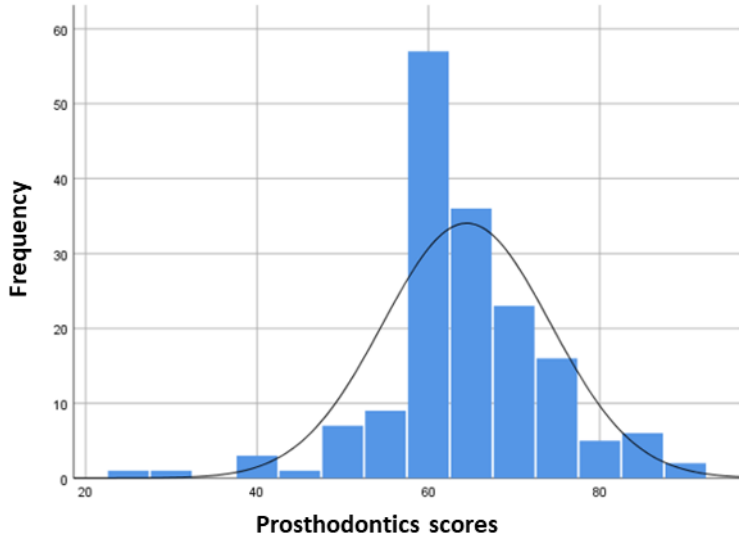
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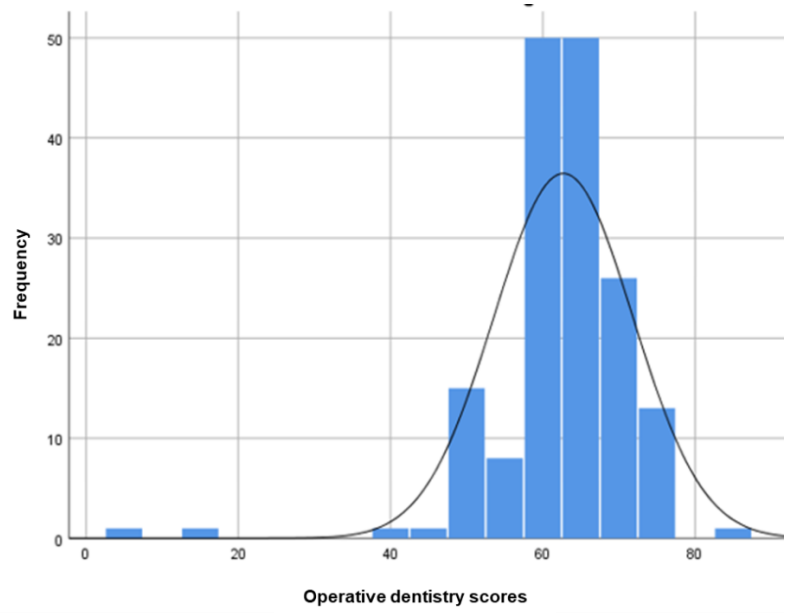
Frequency
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60
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Operative dentistry scores

APPENDIX ONE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Dakalo Mulaudzi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180851

NAME: (Principal Investigator)	Dr Dakalo Mulaudzi
DEPARTMENT:	Oral health Wits University
PROJECT TITLE:	Preadmission requirements as predictors of preclinical success for Dentistry students at the University of the Witwatersrand
DATE CONSIDERED:	31/08/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr MG Thokoane
APPROVED BY:	Doctor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	26/11/2018

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

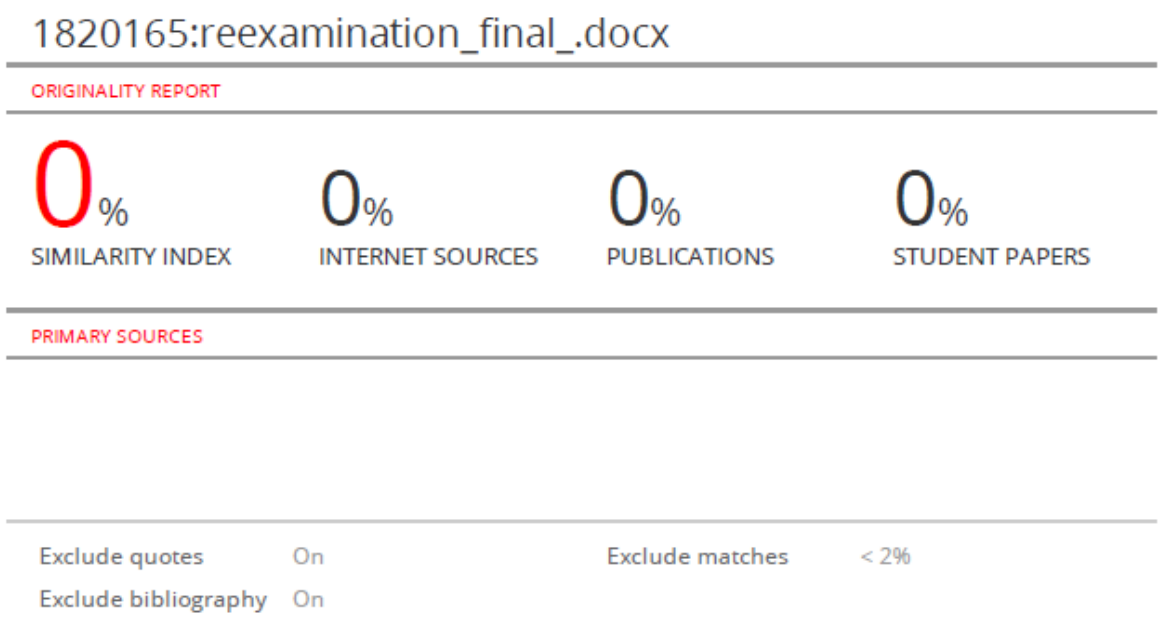
To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Philip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convenes meeting where the study was initially reviewed. In this case, the study was initially reviewed in **August** and will therefore be due in the month of **August** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

04/12/2018
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX TWO



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