Gender Socio-economic and demographic Determinants Predictors of Mathematics Success

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***Abstract*—**The socio-economic and demographic factors have been indicated to predict mathematics success. However, there is paucity of research to verify if these factors differ in predicating mathematics success based on gender (male and female). Hence, this paper reports on a study of gender socio-economic and demographic factors as predictors of mathematics success for civil and built environment students at a comprehensive university in South Africa. Data was obtained through, questionnaire survey from 199 students who were purposive sampled. However, two questionnaires were not valid. The questionnaire was developed from exiting literature. The data was analysed using Statistical Package for the Social Sciences (SPSS) version 22. The statistical analyses computed were both descriptive and inferential. Inferential statistics were used to determine gender socio-economic and demographic variables influencing mathematics success. This was computed using binary logistic regression, splitting gender into male and female. The result established that when male and female socio-economic and demographic variables were tested they were poor predictors of mathematics success. Hence all the variables were insignificant, as the p-values were less than 0.05. However, the descriptive statistics on the socio-economic and demographic factors indicated that male students outperformed the female students in mathematics at high school and at the university. In terms of weekly income majority of the students earned less than R200, with 54% male and 55% for female. It is interesting to note that female students' parents' highest education were far better than male students, as 38% of female students indicated their parents highest education level was university degree compared to 30% of male students. However, the arithmetic difference is not too wide. Furthermore, majority of female students i.e. 74% compared to 61% male students pursued the building course, whereas male students were the majority in civil engineering technology compared to their female counterparts. This study informs university policy makers that where male and female students are accommodated, their age, passing high school mathematics, amount of weekly allowance, entry level to the university and type of education sponsors does not predict passing mathematics at university. However, further research is advocated as these variables are not exhaustive.

***Index Terms*—**Determinants, Engineering, Gender, Mathematics

I. Introduction

Education success is typically measured by higher achievement in assessments. To achieve this success the quality of education is imperative. The quality of education improves the quality of human resources and can be related to increased individual earnings and productivity, and economic growth. However, the poor performance of students might stifle these benefits from being achieved in the Faculty of Engineering and the Built Environment disciplines in South Africa. In supporting this sentiment the vice-dean in charge of academics in the Faculty of Engineering and the Built Environment (university name will remain confidential) indicated that students' performance in mathematics in 2015 was appalling. It was highlighted that in one of the 13 departments in this faculty the students pass rate was 24%. It was suggested in the meeting that the students who failed will be offered lectures on Saturdays. Furthermore, media reports i.e. in newspapers; television and radio have indicated that South Africa has the worst mathematics and science education in the world.

The Basic Education Department's report indicated a 17% decline in the number of candidates who wrote mathematics between 2009 and 2013 from about 290 400 to 241 400 respectively. The candidates who wrote mathematics literacy rose sharply to 58% of the 2013 cohort. Likewise, candidates who wrote physical science decreased by 17% over the same period from roughly 220 900 to 184 300. As the number of learners selecting to do mathematics is dropping, the overall number of learners who are achieving a National School Certificate (NSC) pass with more than 40% in mathematics has been falling over the same period to 17% of the class of 2013. This means the number of students able to do a degree which requires mathematics is very limited – that is, degrees such as engineering, law, accountancy and teaching degrees in mathematics and physical science [1].

South Africa was ranked last of the 143 countries surveyed on the quality of mathematics and science education. The quality of mathematics and science education was extremely poor. In line with this, the quality of its education system South Africa was ranked 139 out of 143 countries surveyed. The mean value was 2.2 in a 7 point Likert scale [2]. This is an indication that the quality of education system in South Africa is not good. This current report supports MacGregor [3] news article, which indicated that vice-chancellors warned the South African government to expect more student drop outs, following shocking results of pilot National Benchmarking Test (NBT) in 2009.

Higher education institutions face greater challenges in relation to mathematics. The NBT results in 2009 revealed that only 7% of students were found to be proficient, therefore ready to study first year mathematics at the university. It was also suggested that majority of students would find it difficult to pass mathematics at university level without additional support [4].

Furthermore, student academic performance has attracted the attention of academic researchers from different fields. They have endeavored to determine which variables impact student performance in positive and negative direction. Researchers have suggested different predictors. For example cognitive predictors [5] which include individual secondary education school grades, SAT Subject Tests and the Pharmacy College Admission [6], National Benchmarking Test [7] and non-cognitive predictors [8][9], which include commitment [10], psychosocial factors [11] and discipline

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[12]. The predictors have also been categorized as academic, cognitive, psychosocial and demographic factors [11].

The different categorization of factors suggests that no consensus has been reached by researchers of what constitutes related and predicting factors for academic success not alone in mathematics as a subject. Determining the factors that are in relation with the student academic performance is important, especially in relation to gender. This will assist institutions and lecturers to find ways to increase the number of successful students, hence positively impacting on their throughput and identify students at risk.

Furthermore, over the past two decades, higher education in South Africa has witnessed a paradigm shift on student enrollment. The reforms in academia since 1994, after the abolition of apartheid have engendered equity and access to higher education to deserving students after completing high school. The inclusivity has brought diversity in the student population in South Africa universities. The need for transformation has been enshrined in government documents, especially empowering the girl child in engineering and built environment disciplines. In line with the aforementioned arguments and discussions, the aim of this research was to undertake a prospective investigation of gender (male and female) socio-economic and demographic factors that are predicators of mathematics success in the current diverse student population in the Faculty of Engineering and the Built Environment.

II. Literature Review

Different studies have suggested the predictors for example lecture attendance of more than ten hours predicted success in general mathematics academic performance for economics students. Furthermore, in their second model they found that attending lectures more than ten hours predicted mathematics success. Students with an average grade of eight (8) and above in mathematics in high school are likely to pass mathematics at the university. Study hours were a predictor of passing mathematics at 10% confidence level [13]. Other study suggested; prior academic achievement, learning styles and academic resources [14]. In a generic study of students' performance achievement, Aromolran et al., [15] found that, student class/year of study and education level of the mother had significant effect on the overall student academic performance. Rajandran et al., [16] conducted a study in Malaysia on student academic performance. They revealed that gender and place of origin as insignificant determinants, the entry qualification as a weak factor, and the student's Cumulative Grade Point Average (CGPA) of entry qualification as the strongest variable that determines the Cumulative Grade Point Average (CGPA) of first year students.

In a study by Uyar and Güngörmüş [17], grade point average, high school type, age of the student and attendance were significant variables which influence student performance. Grade point average, high school type, attendance had positive influence on student performance, whereas age of the student had negative influence. According to Mlambo [18], gender, age, learning preferences, and entry qualifications did not cause any significant variation in the academic performance of students. The researcher suggested further research on other factors that are known to influence academic performance such as: student motivation, socio-economic status and attendance.

Kara et al., [19] found that seven determinants were significant in predictors of learning and success in economics-namely; gender, course (micro vs macro), the number of hours worked, instructor six, whether or not to recommend the course, the number of missed classes, and SAT scores, while the number of hours per week spent on studying for the class, textbook rating were not significant. Moreover, gender, university housing and SAT score had positive effect on students' grades in economics, while the effect of number of missed classes, expected grade at the beginning of the semester and number of hours per week worked at a job was negative. However, Kara et al., [19] in their study they did not test the gender as male and female socio-economic factors separately that predicted learning and economics success.

According to Malik and Basu [20] they found that unit 2 mathematics; mathematics extension 1 and extension 2 are important determinants of students' success in the first year level economics subjects at the university. On the other hand, general mathematics had negative impact on economics subject grades. Ushie, et al., [21] suggested that family structure does not determine students' academic performance, but rather parental socio-economic background.

Adejumo and Adetunji [22] conducted a study using Ordinal Logistic Regression (Proportional Odds Model). The results reveal that only sex of students is not a determinant factor of final grade that students may attain at graduation. This research also suggested that there is equal chance for both male and female students to graduate from a university with First Class. The study further established that younger students perform better than the older ones. The researchers also established that the odds of graduating with First Class are obtained by students who were admitted through Direct Entry (DE). These are students who are academically mature as they have spent at least two academic sessions in their previous college mostly Polytechnics.

The findings of Whannell [23] indicated that, the background information (gender, age, ethnicity, disability, secondary school, work status, and early enrolment) gathered during the enrolment process, does not contain sufficient information for an accurately separation of successful and unsuccessful students. However, Hijazi and Naqvi [24] found that class attendance; mother education and study hours had significant impact on student performance. Class attendance and mother education had positive impact on student performance, while study hours had negative impact.

According to Tewari [25] their findings indicated that matric math score is a better predictor of academic performance of the first year courses at the Faculty of Management, University of KwaZulu-Natal. In a study by Vanthournout et al., [26] they found that academic success is predicted by relating and structuring, lack of regulation, and lack of motivation on students at the end of the year.

It is evident from this discussion that studies have been undertaken to identify and analyze the numerous factors that affect academic performance in various centers of learning. However, few studies have focused on male and female socio-economic and demographic variables especially in the field of engineering and the built environment. This study fills this gap in South Africa context. This study purports that male and female socio-economic and demographic factors are predictors of mathematics success for civil engineering and built environment students.

III. Problem Statement

Mathematics is an important subject for students pursuing engineering and built environment courses locally and internationally. However, despite its importance students at high school have not been performing well according to the Department of Basic Education in South Africa. This same trend has been evident at tertiary institutions where mathematics is taught to engineering and built environment students. Based on this sentiment, researchers have conducted studies to determine the factors predicting academic achievement and to some extend in mathematics. Hence, no consensus has been reached on the socio-economic and demographic determinants that policy advisers in universities can use to identify students at risk in mathematics, specifically in relation to gender. In relation to this gap, this study delved on the following specific research questions –that is:

- Is there influence of male and female socio-economic and demographic variables and mathematics success at the university for engineering and built environment students?

Specific research objectives **are:**

- To determine the influence of male and female socio-economic and demographic factors on mathematics success for engineering and built environment students at the university.

IV. Research Method

A descriptive survey method was adopted, which involved the use of structured questionnaire in an in-depth exploration of the factors underlying the subject matter of the research. Creswell [27] describes a survey as a quantitative or numeric description of some fraction of the population – the sample, which enables researchers to generalize their findings from a sample of respondents to a population within the limitations of the sampling method.

Purposive sampling was used where the researcher selected sample members to conform to the required criterion. Purposive sample can be used for either qualitative or quantitative study, which makes it appropriate for this study. The study population consisted of students from the department of civil engineering technology third years and construction management and quantity surveying third and second years. These were students registered in the 2015 academic year in the Faculty of Engineering and Built Environment (the university name is withheld for confidential purposes). Furthermore, as the questionnaires were completed anonymously, the collection of the data and the presentation of this report cannot harm the respondents or their employing organizations in any way.

The students had been evaluated in mathematics in their previous years. 199 questionnaires were distributed to the students in the middle of the first semester of 2015. All the questionnaires were returned. This high response rate was achieved as the questionnaires were administered under controlled lecture room conditions to ensure the standardization of data gathering. Two of the questionnaires were not suitable for analysis. Therefore, 99% (197) valid questionnaires were used. Content validity was not established as there was no pilot study and pre-testing administered on the questionnaire.

The questionnaire included personal questions about age, gender, students' accommodation, education sponsor, entry to the university, final high school maths result, citizenship, parents' highest education level and weekly allowance. The outcome variable was whether students passed mathematics at first attempt in the first major assessment at the end of the first semester. The response was either Yes or No. Statistical Package for Social Sciences (SPSS) version 22 was used to perform the descriptive and inferential statistics.

Binary logit regression was used to determine gender (male and female) socio-economic and demographic determinants as predicators of the dependent variable of mathematics performance Yes or No. *Yes* response was defined as having passed mathematics at first attempt at the university. Students who did not pass at first attempt were considered to have failed hence responded as *No*. For the outcome analysis, the responses were coded as 1 and 0, respectively. The independent variables of the cross tabulation model were dummy variables that is- gender if male 1 and female 2; students accommodation, on campus 1, off campus 2 and home 3; education sponsor, myself 1, parents/guardian 2, government 3; entry to the university, high school 1 and college 2; final high school maths result, less than 50, 1 and 50 and above 2; citizenship, South African citizen 1, permanent resident 2 and international student 3; and weekly allowance, less than R200, 1, R200-R399, 2; R400-R599, 3 and R600 and above, 4.

Logistic regression is recommended over linear regression when modeling dichotomous responses and allows the researcher to estimate probabilities of the response occurring

$$\ln (p/1\text{-}p) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k \quad (1.1)$$

Where p is the estimated probability of passing, and $x_1, x_2, \ldots, x_k$ are independent variables.

The estimated probability of the response occurring or passing (p) divided by the probability of it not occurring or not passing (1-p) is called the odds ratio. Maximum likelihood method is used to estimate the odds ratios of the model. Values of odds ratios higher than 1 indicate positive association between the variables, odds ratios equal to 1 indicate no association, while odds ratios lower than 1 indicate negative association between each independent variable and the dependent variable of the model.

Furthermore, in order for an independent variable to be a predicator of the dependent variable the p-value should be less than 0.05 at 95% confidence, which connotes its significance in the model. In achieving a fitting model the Hosmer-Lemeshow goodness of fit test should be significant i.e. the value should be greater than 0.05.

V. Results And Discussion

The results indicate that male students are majority, that is- 60.4% pursuing civil engineering and built environment courses at this comprehensive university. The student populations in these departments are predominantly African/black. This domination of African/black students is an indication of transformation within the student population. This is a positive indication 21 years after independence. Furthermore, 92.30% of the students are under the age of 25 years. It is interesting to note that of the 197 respondents only 155 students revealed their age. 55.30% of the parents had tertiary qualification of this percentage, 32.50% had a university qualification. 48.70% of parents/guardians are responsible for their children university tuition fee. A meager 9.60% of students are self-sponsored. 52.80% of the

respondents have a weekly allowance of less than R200.00 as compared 9.8% of students with an allowance more than R600.00. It is important to note that only 26.90% of students are accommodated on campus. This indicates that the university needs to add accommodation facilities for the students. Students residing in the university residence will have enough time to study. Most students 86.7% enrolled to the university directly from high school. It can be suggested that South African students who attend other colleges might not be progressing with their tertiary education. 86.7% of students had passed mathematics at high school when they joined the university. Majority that is- 86.7% of students join the university directly from high school. This is quite encouraging as this is an indication of positive transition from high school to university. The government policy to ensure high school learners to join tertiary or university is yielding dividends.

Table I. indicates the frequencies of gender i.e. male and female and the independent variable and the dependent variable. The results indicate arithmetic differences between male and female and the different independent variables and the dependent variable. The arithmetic differences indicate that majority of female students are 21 years and below. Majority of male students i.e. 28.8% reside at home compared to 13% of the female. Furthermore, most of the female students are accommodated in the university residence than their male counterparts. This difference might arise because female students are venerable to abuse than male students. Hence, they need to be considered first in relation to their safety.

Civil engineering students- that is, male and female were fewer compared to building students in both gender categories. Furthermore, the building course was dominated by female students. Furthermore, male students were dominant in civil engineering programme. It is interesting to note that over 85% of students in both genders pursing these courses joined the university directly from high school. This is encouraging from the South Africa government, as its agenda is to ensure that learners completing matric (high school) should continue with their studies at tertiary level.

The results further indicate that the students of either gender with allowances from R600.00 and above were fewer compared to students with less than R200.00. Majority of male and female students i.e. over 50% had allowance of less than R200.00. In relation to mathematics results in high school, female students were slightly outperformed by their male counterparts. In line with the students who attained more than 50% in mathematics in the university majority were male students. Hence their performance was better than the female students. This result correlates with the high school results in mathematics.

TABLE I
SOCIO-ECONOMIC & DEMOGRAPHIC VARIABLES & MATHEMATICS SUCCESS

Variables		Male	Female
Age group	18-21 years	43.6% (41)	52.5% (32)
	22 - 25 years	48.9% (46)	39.3% (24)
	26 years and above	7.4% (7)	8.2% (5)
Ethnicity/Race	Asian/Indian	0.0% (0)	3.8% (3)
	Black	97.5% (116)	92.3% (72)
	Coloured[1]	1.7% (2)	1.3% (1)
	White	0.8% (1)	2.6% (2)
Citizenship	South African	89.9% (107)	89.7% (70)
	Permanent south African resident	3.4% (4)	3.8% (3)
	Non-South African	6.7% (8)	6.4% (5)
Accommodation	Home	28.8% (34)	13.0% (10)
	On campus	20.3% (24)	37.7% (29)
	Off campus	50.8% (60)	49.4% (38)
Major course	Building construction	60.5% (72)	74.4% (58)
	Civil engineering	39.5% (47)	25.6% (20)
Highest education level of parent/guardian	No schooling	9.3% (11)	3.9% (3)
	Elementary school	0.8% (1)	5.2% (4)
	Secondary/high school	30.5% (36)	29.9% (23)
	College	22.9% (27)	23.4% (18)
	University	29.7% (35)	37.7% (29)
	Do not know	6.8% (8)	0.0% (0)
Entry to university	High school	85.6% (101)	83.3% (68)
	College	14.4% (17)	11.7% (9)
Education sponsor	Myself	10.9% (13)	7.7% (6)
	Parent/guardian	54.6% (65)	39.7% (31)
	Government/bursary	34.5% (41)	52.6% (41)
Weekly income	Less than R200	53.9% (62)	55.3% (42)
	Between 200 and 399	27.0% (31)	18.4% (14)
	Between 400 and 599	8.70% (10)	18.4% (14)
	600 and above	10.4% (12)	7.9% (6)
Final mark high school	Less than 50	10.3% (12)	17.9% (14)
	50 and above	89.7% (105)	82.1% (64)
Mathematics result university	No	15.1% (18)	24.4% (19)
	Yes	84.9% (101)	75.6% (59)

The number in the parenthesis indicates the actual number of respondents

Table II presents the results of students' gender socio-economic and demographic predicators of mathematics success. The study found that the relationship of the independent variables and dependant variable mathematics success were insignificant as the p-value were less than 0.05, based on the gender (male/female) socioeconomic and demographic factors. These factors were citizenship, students' accommodation, education sponsor, entry to the university, final high school maths result and weekly allowance. These finding therefore rejects the hypothesis that gender socio-economic and demographic factors predicts mathematics success.

However, prior to testing this model, the goodness of fit

[1] Mixed ethnicity in South Africa

of the model was tested which indicated a good fit. This result was justified by the Hosmer and Lemeshow test. The significance of the model was greater than 0.05 at 0.985 for male and 0.340 for female. The result suggests that the independent variables were fitting in the proposed theoretical model.

TABLE II
BINARY LOGIT ON GENDER (MALE/FEMALE) AND VARIABLES OF PASSING MATHEMATICS

Male Variables	**B**	**Sig.**	**Exp. (B) Odd ratio**	**Lower 95 % C.I.**	**Upper 95 % C.I.**
Citizenship		0.91			
Permanent resident (1)	19.73	0.99	368439202.35	0.00	
Non South African (2)	0.53	0.67	1.696	0.16	18.49
Accommodation		0.80			
On campus (1)	0.59	0.54	1.812	0.27	12.08
Off campus (2)	0.02	0.98	1.015	0.25	4.14
Entry to university (college) (1)	-1.40	0.08	0.246	0.06	1.18
Education sponsor		0.18			
Parent/guardian (1)	-19.88	1.00	0.000	0.00	
Government (2)	-18.37	1.00	0.000	0.00	
Weekly allowance		0.90			
R200-R399 (1)	0.12	0.86	1.127	0.29	4.38
R400-R599 (2)	-0.66	0.49	0.515	0.08	3.42
Over R600 (3)	18.87	1.00	156190919.29	0.00	
Final high school mark 50 and above (1)	0.84	0.33	2.318	0.42	12.74
Constant	20.48	1.00	784850929.81		
Female Variables	**B**	**Sig.**	**Exp. (B) Odd ratio**	**Lower 95% C.I.**	**Upper 95% C.I.**
Citizenship		0.96			
Permanent resident (1)	0.06	0.96	1.063	0.08	14.99
Non South African (2)	0.45	0.79	1.570	0.06	42.92
Accommodation		0.87			
On campus (1)	0.50	0.60	1.644	0.26	10.58
Off campus (2)	0.42	0.64	1.515	0.27	8.53
Entry to university (college) (1)	-0.83	0.45	0.438	0.05	3.75
Education sponsor		0.67			
Parent/guardian (1)	-0.73	0.61	0.483	0.03	7.67
Government (2)	-1.09	0.44	0.336	0.02	5.21
Weekly allowance		0.99			
R200-R399 (1)	0.19	0.80	1.215	0.27	5.54
R400-R599 (2)	-0.07	0.93	0.935	0.23	3.90
Over R600 (3)	20.21	1.00	600134365.61	0.00	
Final high school mark 50 and above (1)	0.14	0.84	1.51	0.29	4.53
Constant	1.38	0.36	3.98		

CONT'D TABLE II
BINARY LOGIT ON GENDER (MALE/FEMALE) AND VARIABLES OF PASSING MATHEMATICS

Dependent variable: Passing mathematics at University (0=No; 1=Yes) sig. at 5%

VI. CONCLUSIONS AND RECOMMENDATIONS

The study found that the relationship of the independent variables and dependant variable mathematics success were insignificant based on the gender socioeconomic and demographic factors. These factors were citizenship, students' accommodation, education sponsor, entry to the university, final high school maths result and weekly allowance. However, in relation to arithmetic percentages, the findings suggest that female students were less likely to pass mathematics at their first attempt in the university compared to male students. Male students' were in civil engineering course compared building students. Majority of female students resided within the university compared to their male counterparts. Based on these findings, the researchers recommend that:

Despite insignificant prediction of the gender socio-economic variables on mathematics success, however the percentage differences suggest that, the university should inform the female students to be studious in the quest to pass mathematics at their first attempt in their course. More assistance will be required for female students in order to succeed in mathematics. The additional support to this cohort of students will ensure timely completion of their studies and not to waste their finances. The study also suggests that the university should invest on student accommodations that are affordable. This will assist students to operate in close proximity to their study environment and hence not waste time in travelling to the university. Furthermore, the myth that construction is male dominated is challenged in this study as the indication in the building course suggests the number of female students has increased. However, this is not the case with civil engineering technology.

This study is timely taking the history of South Africa higher education in consideration. With the expansion of South Africa University infrastructure, and the quest for education among matric learners, comes an increased diversity of the number of students registered in the university. To fully support the diversity of students, universities must implement strategies and interventions based on sound research studies that will ensure students are given a fair chance to succeed. Hence, the need to continue to identify factors that would influence student academic performance in mathematics and other discipline becomes crucial.

Therefore the researchers propose the need to use other determinants in relation to the socio-economic and demographic factors as these factors are not exhaustive in

relation to the full characteristic of a student. This suggestion is critical as the correlation of the factors and mathematics success is weak. The other factors recommended for testing are extra-curricular activities the student is involved in at the university and their study skills. A further study is also recommended for all Engineering and Built Environment courses at this University.

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