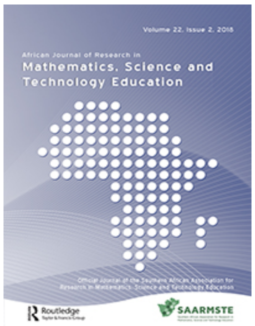

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An Analysis of Academic and Institutional Factors Affecting Graduation Among Engineering Students at a South African University

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The study investigated the relationship between timely graduation and academic and institutional factors for a cohort of Engineering students at a South African university. The sample was restricted to 1595 incoming students beginning during 2009–2011 who were tracked to 2016, allowing for an eight-year graduation period for the initial cohort. Both descriptive statistics and regression models were employed in the analysis. The results demonstrate that the characteristic profile of a student graduating on time in the Engineering programme is likely to be non-African, have high admission point scores (above 40), pass more than 75% of their credits in the first year, have financial aid and make regular use of Supplemental Instruction. In other words, students who have financial and prior academic advantages are the most likely graduates. These results suggest that universities should give serious consideration to academic support and financial aid provision.

Keywords: *Time to graduation; Engineering; supplemental instruction; financial support*

Introduction

Concerns about student retention and throughput are endemic to higher education institutions (HEIs) and have been the subject of research and policy debates since the massification of higher education in South Africa (Manik, 2015; Scott, 2012). Studies mostly drawn from the field of education and academic development (see Scott, Yeld & Hendry, 2007; Boughey, 2005) have laid the conceptual foundations for both scholarly inquiry and policy initiatives. The consensus from these studies is that there is low participation in higher education which is compounded by high attrition (Fisher & Scott, 2011) and is largely driven by the inequities in education attainment that the country has struggled to address since the advent of democracy. Although the South African government has increased education campaigns and invested in access to and success in higher education since then (Rarieya, Sanger & Moolman, 2014), there is a body of research which points to disparities in educational attainment across racial and socio-economic lines, a status quo which perpetuates intergenerational inequalities (Spaull, 2015; Rarieya et al., 2014).

Amidst these concerns with attrition and participation in higher education is an increasing demand for Engineering skills in South Africa, the shortage of which poses a long-term challenge for social and economic development (Fisher, 2011). Undoubtedly university graduation is a measure of skill injection into the labour market (Alais, 2017). However, the available evidence suggests that 50% of students entering higher education leave prior to graduation (Department of Higher Education and Training, 2016). While Engineering programmes tend to have lower dropout rates than other fields (Pocock, 2012), there are still concerns that the students are taking a long period of time to graduate. The Engineering Council of South Africa throughput study (Fisher, 2011) found that completion in minimum time ranged from 10% to about 45% at the different universities with total completion rates ranging between 35 and 60%. The Council for Higher Education's (2013) review of undergraduate programmes also found that approximately 40% of Engineering students graduate in five years. Similar concerns with low throughput in Engineering have been raised in other countries (Geisinger & Raman, 2013, for the USA; Godfrey, Aubrey & King, 2010, for Australia).

Clearly, such high attrition rates are a significant problem for both students and higher education institutions. For instance, most of these students are likely to leave higher education institutions having accrued debts in unpaid tuition fees (Pocock, 2012). Even in cases where the tuition fees are fully paid, such students might not easily make up the lost fees through employment. This is because individuals with less than a university degree are likely to experience lower lifetime earnings (Thurlow & Johnson, 2011). Evidence from Statistics South Africa (2014) reveals that ~23.6% of individuals with only a high school leaving certificate were living in poverty compared with less than 5% (one in 20) of those with a tertiary education. Cast in this way, failure to graduate from university points to educational inequality and raises questions such as: what are the factors which influence university graduation in South Africa? Answering this question is important for HEIs which must operate like any other business, where the losses and gains are known. In addition, the use of statistical methods in answering this question provides empirical evidence with a high degree of accuracy which can be used in measuring evidence and planning.

Determinants of University Graduation

Studies have identified a range of student background factors which influence academic outcomes (see for instance the recent study by Gershenfeld, Hood & Zhan, 2016). In South Africa, the issues of race, family socio-economic status (Branson, Hofmeyr & Lam, 2014) and a historically differentiated education system have been brought to the fore (Spaull, 2015). Students who come from disadvantaged backgrounds have been found to have negative educational outcomes (Spaull, 2015; Scott et al., 2007) which have been attributed to socio-economic status, race, language and the quality of the educational system. Regarding gender, there is consensus that female participation at all educational levels has improved, with females outperforming their male counterparts in some cases (Moletsane & Reddy, 2011). However, there are still concerns that gender inequality persists in other forms such as the uptake of Science Technology, Engineering and Maths (STEM) subjects (Raireya et al., 2014; Moletsane & Reddy, 2011).

Persistence studies in Engineering education have also identified factors that lead students to drop out from Engineering programmes. A systematic review of literature on persistence in Engineering in the USA (Geisinger & Raman, 2013) found that students drop out because of the classroom and academic climate; grades and conceptual understanding; self-efficacy and self-confidence; high school preparation; career aspirations; and race and gender. In a review of journal articles on science education in South Africa, Venkat, Adler, Rollnick, Setati & Vhurumuku (2009) pointed to the effect of metacognition, teaching approaches and communication on student success in mathematics and science. A study by Pocock (2012) found that financial reasons and academic preparedness were the major reasons leading to student attrition in Engineering at a South African university while an earlier study by Jawitz (1995) established that academic performance in the first year was a good predictor for future academic success in Engineering programmes.

While the available evidence points to several factors which affect student success in HEIs, there is limited quantitative research in South Africa which has brought all these factors together. Where these have been explored, the tendency has been to provide conceptual understandings (Manik, 2015) or examine the perceptions of a limited number of students through focus group interviews (Moodley & Singh, 2015). Further, the inclination in throughput studies has been to report the graduation rates in terms of percentage completed per cohort (Letseka & Maile, 2008), while taking into consideration a limited number of factors such as admission point scores, gender and race. However, the low throughput rates, especially for the African students (Council for Higher Education, 2013), are increasingly putting pressure on higher education institutions to ensure that students graduate. Students on the other hand have called on institutions to be accountable for the quality of education they offer and have questioned the enduring inequities in student outcomes through protest movements such as #RhodesMustFall and #FeesMustFall (Mubangizi, 2016). These pressures are pushing HEIs to reconsider the way things have always been done and to find new solutions to the crises (Dhunpath, Amin & Msibi, 2015). One such way is the use of institution-wide data collected from a range of sources to have a more fine-grained insight into student achievement. The modest research using survival analysis has enabled researchers to explore how some of these factors affect the length of time (in years) it takes students to graduate (Zewotir, North & Murray, 2015; Murray, 2014). We also acknowledge Pocock's (2012) study on leaving rates and reasons for leaving in an Engineering faculty. However, still little is known about how individual, institutional and academic factors come together to influence timely graduation in Engineering. The current study sought to take the existing evidence further by examining in the same analysis the effect of multiple factors on student throughput.

Theoretical Perspectives

This study is informed by Tinto's model of student integration (Tinto, 1993) and Swail's retention model (Swail, 1995). Tinto (1993) theorised that students who manage to integrate both academically and socially are more likely to persist and graduate from university. Further, he reasoned that active student engagement was the pillar of student success which focused on how students learn, rather than how students should be taught (Tinto, 1999). In addition, the extent to which a student is able to integrate academically is dependent on his or her pre-university characteristics such as schooling, family background and prior academic achievement. Like Tinto, Swail's theory (1995) identified five pillars of student success, each representative of critical service departments in most universities: financial aid; recruitment and admissions; curriculum and instruction; academic services; and student services. Both of these models have influenced a number of studies in South Africa (for instance Pocock, 2012; Ramrathan & Pillay, 2015).

In this study, it is assumed that academic factors such as the first-year aggregate credits, and institutional factors such as university-based residence, supplemental instruction and financial aid increase the likelihood of graduating. In addition, we assume that factors such as admission point scores and the socio-economic status of the school where a student did his or her high school should be associated with degree persistence.

Methodology

The data for this study were drawn from the cohort data archived in the department of Institutional Intelligence at the University of KwaZulu–Natal. This dataset contained information on student biographical factors such as race and gender; academic characteristics—admission point scores and academic performance in the first year; and institutional factors—financial aid and residence status. This data set was supplemented with data from the School of Engineering on uptake of Supplemental Instruction (SI), a peer learning programme that is attached to traditionally difficult courses with the aim of enhancing student performance and retention (Malm, Bryngfors & Mörner, 2012). Although the SI programme is available to all students, attendance is voluntary. The sample for this study comprised incoming students beginning 2009–2011 who were tracked to 2016, allowing for an eight-year graduation period for the initial cohort. The study took a census approach and examined the entire population of first-year incoming students into the Engineering programme for 2009 (456), 2010 (502) and 2011 (637), resulting in a total sample of 1595.

Dependant Variables

Graduation (0 = no, 1 = yes) indicated whether an individual had graduated from the initial qualification they were registered for or not. This measure has been used in previous research and is a crude measure of the year-to-year retention (Geisinger & Raman, 2013). Therefore, this indicator did not take into consideration the time to graduation or graduation from subsequent qualifications for those who might have switched to other programmes. Time to graduation (*time to graduation* (4 = *regulation* *time*, 5 = *regulation time* + *1 year*, 6 = *regulation time* + *2 years and above*)) measured the time individuals took to complete their degree programme. The Engineering programme is a four year qualification; therefore, students who graduate in four years are deemed to have graduated in the regulation time. Like the graduation, this variable was restricted to graduation within the initial registered qualification.

Independent Variables

Demographic data

Demographic data included data on gender and race. Owing to the small sample size for the Indians, Whites and Coloureds, and in order to avoid over- or under-estimating the coefficients in the regression analysis, the race variable was collapsed into two categories to represent (1 = Other, 2 = African; the term African as used in this paper refers to black South Africans).

Academic data

For the Academic data two sets of academic data were used. The first was the pre-university academic data (admission point scores, APS) and university level, i.e. students' credits accumulated at the end of the first year (<75 = 1, >75 = 2). The APS were coded as a four-level categorical variable (0 = alternative qualification; 1 = 30–35; 2 = 36–39; 3 = 40–48). This categorisation was based on the trends observed in the data regarding admission into the various Engineering disciplines at the University of KwaZulu–Natal. We also removed students who had APS points below 30 (nine cases) from the analyses which included APS scores. We assumed that, since this group had very low APS scores, they would perform differently from those whose APS scores were above 30. Students who had alternative entry qualifications would have written different school leaving examinations from the National Senior Certificate written in government-funded schools.

Institutional data

Pre-university institutional data included school ranking quintile 1 being the lowest and most disadvantaged and quintile 5 the highest and most advantaged school. To stabilise the co-efficient in the regression analyses, quintiles 1–3 were combined since they constituted a small proportion of the sample. Moreover, these quintiles are generally classified as disadvantaged; thus, the combination did not alter the characteristics of the original data. University-level institutional data included SI attendance registers, financial aid status (1 = yes, 2 = no) and whether or not a student had university residence (1 = yes, 2 = no). SI attendance was coded as a three-level categorical variable (0 = never attended; 1 = some attendance; 2 = regular attendance). Students who attended at least five SI sessions in a given module were considered regular attendees.

Analytical Strategy

Both descriptive statistics and regression models were employed in the analysis. For the dependent variable *graduation* (0 = no, 1 = yes), four logistic regression models were estimated. Model 1 examined the effect of demographic factors, while Model 2 included pre-university characteristics (APS and school quintile). In Model 3, the student's academic performance at the end of the first university year was controlled for while the final Model 4 adjusted for institutional (university) factors (academic support, residence and financial aid).

For the dependent variable *time to graduation*, two multinomial models were estimated. The first model included independent effects of each of the variables while the second model included all of the variables.

Results

Table 1 reports the descriptive statistics in frequencies and percentages of the selected variables by graduation status. Chi-square test statistics are also included. These statistics seek to answer the question: does graduation from the Engineering programme depend on the selected variables?

Table 1. Descriptive statistics of independent variables and test of significance with graduation status ($N = 1595$)

Variable	Frequency (N =)	N = total	Percentage	Significance
Gender				
Male	552	1159	47.6	NS
Female	214	436	49.0	
Race				
African	205	547	37.5	***
Other	561	1048	53.5	
School quintile				
Lower quintile	51	165	30.9	***
Quintile 4	129	260	59.6	
Quintile 5	412	809	50.9	
APS scores				***
Alternative	62	183	33.9	
40–48	378	562	67.3	
36–39	214	527	40.6	
30–35	75	261	28.7	
Credit accumulated				***
>75% aggregate	740	1115	66.4	
<75% aggregate	26	480	5.4	
Academic support				***
None	250	870	28.7	
Some	395	563	70.2	
Regular	121	162	74.7	
Financial aid				***
Yes	487	901	54.1	
No	279	694	40.2	
Residence				***
Yes	116	339	34.2	
No	650	1256	51.8	

*** $p < 0.005$.

Exploratory Data Analysis

There was no statistically significant difference in graduation rates between males (47.6%) and females (49.0%). Only 37.5% of the African students had graduated by 2016 relative to 53.5% of the other races (Indian, White and Coloured).

Only 30% of students from lower quintile schools had graduated as compared with 59.6 and 50.9% of those from quintiles 4 and 5 respectively. As expected, most students with high APS scores (40–48, 67.3%) had graduated. In comparison, only 28.7% of those with APS scores between 30 and 35, 40.6% of those with APS scores between 36 and 39 APS scores, and 33.9% of those with alternative APS scores had graduated by the same date. In terms of first-year accumulated credit points, 66.4% students who had passed more than 75% of their total credit points at the end of the first year had graduated, compared with only 5% of those who did not obtain 75% of their first-year credits. Most of the students who made regular use (74.7%) or some use (70.2%) of SI sessions had graduated relative to 28.7% of those who had never attended an SI session. More than half of the students who had financial aid (54.1%) had graduated by 2016. Regarding university residence, 51.8% of those who did not live in university residences had graduated by the same period. There was a low graduation rate (34.2%) among students who stayed in university residences. Most of our variables significantly predicted graduation from the Engineering programme with p-values <0.005. The gender variable was not significant in the chi-square tests.

As already indicated, the graduation rate data is a crude measure as it does not distinguish the time taken to graduate. Figure 1, therefore, presents the descriptive statistics for time taken to graduate per

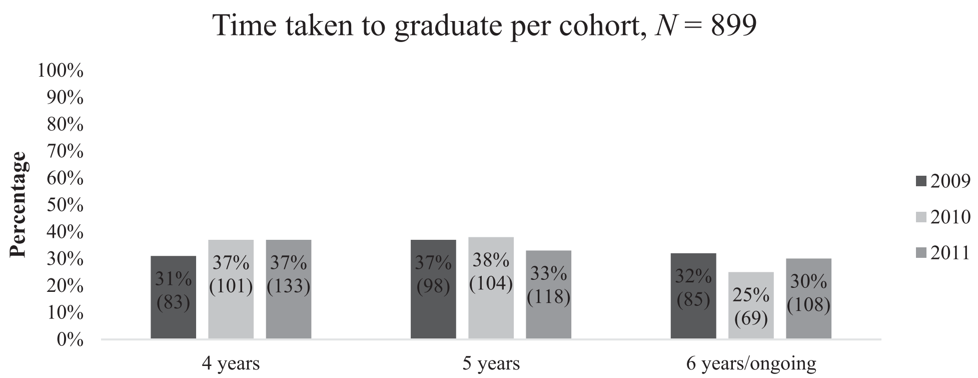

Figure 1. Time taken to graduate, 2009–2011 first time entry Engineering students

cohort, 2009–2011. Students who took six years to complete and those who were still registered for the same Engineering programme were grouped together for this analysis. This grouping was based on the plausible assumption that, across all cohorts, the ongoing students would have been registered for the Engineering programme for at least six years. A total of 696 students were also excluded at this stage of the analysis as they had either dropped out ($N = 579$) or had been excluded ($N = 117$) from the Engineering programme.

It can be seen from Figure 1 that 31% of students from the 2009 cohort, and 37% from both the 2010 and 2011 cohorts, had graduated in the regulation time. The five-year completion rate ranged from 33% for the 2011 cohort and 37 and 38% for the 2009 and 2010 cohorts, respectively. Thirty-two per cent of students from the 2009 cohort were either ongoing or had completed in six years as compared with 25% from the 2010 cohort and 30% from the 2011 cohort.

Regression Analysis

Tables 2 and 3 present results from the regression analysis and seek to answer the question: is there a particular combination of factors which increases the probability of graduating amongst Engineering students? This analysis presents the crude graduation rates from the Engineering programme and does not take into consideration the time taken to graduate.

In Model 1 (Table 2), relative to African students, other (Indians, Coloureds and Whites) students were 92% [$1 - \exp(1.921 \times 100)$] more likely to graduate. This effect was consistent across all models, increasing the most in Model 4, when institutional factors were added. In Model 2, male students were up to 56% more likely to graduate than females, while the effect of lower quintile schools was positive but not statistically significant. Students with 40–48 APS scores were up to 5 times more likely to graduate, while those with 36–39 APS scores were 1.7 times likely to also graduate relative to those with 30–35 points.

The positive effect of alternative entry points on graduation was not statistically significant. In Model 3, the credits accumulated showed the greatest positive effect on graduation (odds, 31.95). That is, students who passed more than 75% of their first-year credits were up to approximately 32 times more likely to graduate than those who failed to acquire 75% of their first-year credits. In the final model, both regular and some attendance of SI sessions increased the probability of graduating by up to 4 times. Having financial aid increased the odds of graduating by about 34% while the results for residence on campus were not statistically significant.

Using the time taken to graduate measure (Table 3), the results demonstrate that being male and non-African was positively associated with graduating in four or five years. The effect of lower school quintiles (1–3) was negative for both individuals who took four or five years to graduate, although this was not statistically significant in the Full Models. The effect of quintile 4 was not statistically significant in all models. Higher admission point scores (40–48 points) increased the odds of graduating in regulation time by the greatest factor of 7.9, although this effect weakened for those

Table 2. Logistic regression models of crude graduation rates for the Engineering cohorts, 2009–2011 (*N* = 1595)

	Model 1		Model 2		Model 3		Model 4	
Variables	OR	SE	OR	SE	OR	SE	OR	SE
Gender (female ref.)								
Male	0.993	0.114	1.563***	0.140	1.285	0.166	1.547**	0.178
Race (African ref.)								
Other	1.921***	0.108	1.968***	0.181	**2.251*****	0.206	2.**533*****	0.305
School quintile (5 ref.)								
Quintile 4			1.169	0.248	1.040	0.277	1.037	0.300
Quintile 1			1.306*	0.161	1.149	0.190	1.066	0.200
APS scores (30–35 ref.)								
Alternative			1.213	0.317	1.516**	0.378	1.499	0.406
40–48			**4.927*****	0.193	**2.887*****	0.225	1.853**	0.253
36–39			1.729***	0.184	1.677**	0.218	1.442**	0.233
Credits accumulated (<75% ref.)								
>75%					**31.950*****	0.241	**24.014*****	0.246
SI (none ref.)								
Some SI							**3.937*****	0.167
Regular SI							**4.788*****	0.263
Financial aid (no ref.)								
Yes							1.342*	0.182
Residence (no ref.)								
Yes							0.733	0.327
−2LL	2171.229		1543.969		1151.430		1063.623	

SI, Supplemental instruction; OR, odds ratio; SE, standard error; ref., reference category; -2LL, the log likelihood ratio of the models.
* $p < 0.10$; * $p < 0.05$; *** $p < 0.005$.

students who took up to five years to graduate. The results for the category 36–39 APS scores were positive and significant for the students who took the minimum time to graduate relative to those who were either in the pipeline or took more than six years to graduate. Our descriptive analysis (frequencies) revealed that all the students who had graduated in the regulation time had acquired more than 75% of their credits in the first year. As a result, SPSS could not produce any meaningful statistics for this category as there were cells with zero cases. Therefore, and as shown in Table 3, we did not include any results for the analysis of credits accumulated for the 4 year graduation variable. Our analysis, however, shows that passing more than 75% of the first-year credits was also beneficial for graduating in regulation time plus one year and increased the probability by a factor of 9.1, univariate model and 8.7, full model. Some SI attendance increased the odds of on-time graduation by about 70% (univariate model) and 93% (full model), while regular SI attendees were 2 times likely to graduate in the regulation time (odds 2.4, univariate model; odds 2.3, full model). This effect was insignificant for those who took five years to graduate relative to those who were either still in the pipeline or had graduated in six or more years. Students who had financial aid were up to 55% more likely to graduate in four years relative to those who did not have aid. Having on campus residence was also negatively associated with both four year and five year graduation rates in the univariate models. This effect became positive in the full models, although not significant. Notably, most of our variables (except for school quintile 4) accounted for the gaps in graduation rates for individuals who graduated in four years relative to those who graduated in six years or were still enrolled in the Engineering programme.

Discussion and Conclusion

The aim of this study was to test the effect of pre-university and university academic and institutional factors on timely graduation rates in the School of Engineering at the University of KwaZulu–Natal. The

Table 3. Multinomial regression models for time taken to graduate for the Engineering cohorts, 2009–2011 ($N = 899$)

	4 Years				5 Years			
	Univariate model		Full model		Univariate model		Full model	
Variables	OR	SE	OR	SE	OR	SE	OR	SE
Gender (female ref.)								
Male	1.473**	0.184	2.112***	0.242	1.290	0.181	1.494*	0.227
Race (African ref.)								
Other	1.831***	0.183	2.249**	0.409	1.626**	0.179	3.366****	0.407
School quintile (5 ref.)								
Quintiles 1–3	0.267**	0.340	0.546	0.470	0.441	0.290	0.745	0.405
Quintile 4	0.736	0.234	0.811	0.267	0.844	0.227	0.938	0.249
APS scores (30–35 ref.)								
Alternative	5.944***	0.419	3.589*	0.689	1.409	0.381	1.338	0.599
40–48	**7.919*** **	0.327	**5.323*** **	0.433	1.829**	0.251	1.339	0.339
36–39	2.262**	0.344	2.078*	0.423	1.409	0.343	1.314	0.308
Credits accumulated (<75% ref.)								
>75%					**9.181*** **	0.371	**8.753*** **	0.408
SI (none ref.)								
Some SI	1.696***	0.184	1.934**	0.245	1.117	0.111	1.244	0.219
Regular SI	**2.396*** **	0.272	**2.307***	0.338	1.527	0.272	1.476	0.319
Financial aid (no ref.)								
Yes	1.546**	0.174	1.089	0.266	1.083	0.170	0.864	0.243
Residence (no ref.)								
Yes	0.400***	0.226	1.235	0.491	0.602**	0.208	1.838	0.453
−2LL	715.425.							
Intercept	535.338.							
Full model								

* $p < 0.10$; * $p < 0.05$; *** $p < 0.005$. All models are compared against the 6 year graduation rate.

results are based on the analysis of 1595 Engineering students enrolled for the first time in 2009, 2010 and 2011. Among the demographic attributes, males were found to have better odds of graduating in regulation time than females. It was also clear that the percentage of credit points accumulated in the first year, high admission point scores (40 and above) and regular uptake of SI were the strongest predictors of both crude graduation rates and ‘time to graduation’ amongst Engineering students. Overall, our results are consistent with both Tinto (1993) and Swail (1993) and illustrate that there are multiple factors (academic and institutional) which influence student academic outcomes.

Our findings suggest that the African students were less likely to graduate in regulation time relative to the ‘other’ racial groups. However, the 2013 Council for Higher Education review found that graduation in regulation time was very low for all racial groups, while the African students performed comparatively similar to the Indians and the Coloureds. Mindful of this dynamic, we conducted supplementary analyses where we compared African vs Indian students only as these racial groups had comparable numbers of students. Still, our results showed that African students had a lower throughput than the Indian students. Thus, these findings reinforce the significance of the racial disparities in achievement in STEM subjects (Moletsane & Reddy, 2011). Our finding regarding gender is also consistent with extant literature on gender inequalities in education. The fact that females are underrepresented in STEM fields like Engineering is well documented, although efforts have been made to remedy the situation our results, and those from prior studies (Moletsane & Reddy, 2011) indicate that males continue to dominate the field. Raireya et al. (2014), like Moletsane and Reddy (2011), note with concern that these imbalances are a result of how boys and girls are socialised differently at home and this also plays out in the education system. In other words, females are socialised away from STEM fields and those who do join STEM fields are most likely to lack the competitiveness of their male counterparts.

There is literature which has demonstrated that entry level qualifications influence timely graduation because they are associated with first-year academic performance. For instance, Bush (2012) found that students who came in with high entry points attained consistently better grades than those with lower points. This evidence is further supported by Jansen (2004) and by McKenzie and Schweitzer (2001) who suggest that students who perform exceptionally well in secondary school are more likely to do well throughout their academic career. However, in South Africa, the relevance of admission point scores for university success has been questioned (Schaap & Luwes, 2013). This is largely due to the inadequacies of the curriculum and the differences in educational opportunities and standards at the school level (Spaull, 2015). These criticisms notwithstanding, the studies by Bokana and Tewari (2014) as well as Naidoo, Motala and Joubert (2013) found that students with higher APS scores (above 40) had better education outcomes in university. Thus, we conclude, similar to these prior studies, that students with higher APS scores are more likely to graduate in the minimum time.

Prior research has shown that lower school SES associates negatively with educational outcomes (Visser, Juan & Feza, 2015; Spaull, 2015). Thus, we expected that school quintile would be a potent indicator of university performance. However, our results indicate that school quintile had a negative but insignificant effect on graduation rates. However, these results must be interpreted with a caveat. The variable was unevenly distributed, with more students coming from quintile 5 schools. When disaggregated by race, less than 100 African students came from quintile 5 schools, suggesting that most students in the Engineering programmes were non-Africans. This presents a challenge for regression analysis with unequal sample sizes and can potentially destabilise the co-efficient. Thus, these results should not be used to suggest that school quintile has no effect on graduation rates.

The findings from this study also provide evidence of the efficacy of SI as an academic support mechanism and show that students who regularly attended SI were more likely to graduate and in minimum time. This result is consistent with findings from Bowles, McCoy and Bates (2008) who found that regular uptake of SI increased timely graduation by about 11%. Malm, Bryngfors and Mörner (2015) found a positive correlation between regular SI attendance credit attainment and students performance during the first year of Engineering studies. In addition, there are studies, drawing from Tinto's theory of retention, which have demonstrated that students who are actively involved in academic support services such as SI (Cuseo, Fecas & Thompson, 2007) have better outcomes. This effect is elevated if students make use of such services as early as their first year of study (Cuseo et al., 2007). However, given that SI attendance is voluntary, and therefore students self-select to attend, there is a need to understand the profile of students who make use of it. It could be that the observed effect might not be due to SI attendance *per se,* but rather due to other unobserved factors such as student motivation. This limitation notwithstanding, the results from this study suggest that SI is an important condition for student success (Tinto, 1999) and, hence, a strategy that can enhance retention and increase throughput.

The finding that performance in first year leads to persistence is echoed in prior research (Gershenfeld, Hood & Zhan, 2016; Jawitz, 1995). Although the first year is acknowledged as a critical transition which lays the foundation for subsequent academic success and persistence in South Africa (Manik, 2015) and even with different interventions put in place to support students, there is limited research from South Africa exploring the role of the first-year academic performance on graduation rates. It may also be worth noting that Engineering is a structured degree, where progression depends on the successful completion of prior modules. Hence, failing a module threatens a student's chances of completing the degree on time. This perhaps explains why, in addition to what the literature says about integration, acquiring more than 75% of the first-year credits showed the greatest effect on timely graduation.

This brings our attention to financial aid and university residence. Our results show that, for the most part, financial aid had a positive effect on crude graduation rates and the four-year graduation rate relative to those who take six years and above. The studies by Pocock (2012) and Bokana (2010) both found that, apart from academic factors, lack of financial aid was one of the main reasons why students did not persist to graduation. The finding that financial aid may be able to improve graduation rates is important, especially considering the recent spurt of no-fees campaigns in South African universities. In this regard, financial aid remains a central factor hindering students' graduation outcomes and these findings call on universities to reconsider student funding. Finally, we found that staying in university residence was negatively associated with graduation rates for the Engineering cohort. International studies have shown that students who have on campus residence have better outcomes as they are more likely to have more time to study (López Turley & Wodtke, 2010). However, in South Africa, university residence has been the least investigated determinant of university persistence. Therefore, there are fewer comparable studies. The PhD study by Bokana (2010) used both qualitative and quantitative methods and found that university residence was not the most ideal for a number of reasons. These include lack of safety and security, irregularity of public transport to or from the university and unhygienic living conditions. It may also be worth noting that University of KwaZulu–Natal is a non-residential university since most of the students stay at home. Supplemental analysis, available on request, also showed that most of the students who stayed in residences came from the lower quintile schools. Thus, apart from the conditions in the residences, there is a possibility that students who live in university residences also come from disadvantaged backgrounds.

There are several practical implications for these findings. Firstly, the relationship between Supplemental Instruction and throughput should be given serious consideration by university departments, administrators and the Department of Education. This needs to be done in an evidence-based manner, thus, additional work needs to be undertaken to establish the effect of SI, while taking into consideration the self-selection bias. Secondly, since academic performance in the first year is positively associated with timely graduation, universities should consider investing in more academic support in the first year as well as coming up with early warning systems to identify students at risk of failing the first year. Lastly, the impact of financial aid on academic attainment should be of interest to policy makers and efforts should be made to ensure that the majority of students get financial aid.

The results from this study should be considered in the context of the study's weaknesses. First, the analysis was limited to the factors available in the data. As such, there are questions which may arise, but cannot be addressed using this data. For instance, other variables of interest would have been family socio-economic status, students' study habits and metacognition. In South Africa, language is a major determinant of student learning and there is a need for research which also models the effect of language on graduation rates. In addition, the methods of analysis used in the study do not allow for causal inferences. Hence, they should be interpreted as associations between the variables investigated and timely graduation. Combining these findings with qualitative data might also provide a deeper grained understanding of how these factors work together to influence academic outcomes.

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No potential conflict of interest was reported by the authors.

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