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Factors related to throughput in final-year Statistics

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This article reports on the results of a study examining factors related to throughput at the University of the Western Cape (UWC) in South Africa between 1975 and 2001. The students in the study all registered for at least one semester of Statistics in their final year. Throughput is defined as the number of years taken by a student to complete an undergraduate degree and is described in terms of the following factors: Grade 12 aggregate, home language and Grade 12 Mathematics result. The study adopted a quantitative approach and used historical student records. The most significant factor was found to be the Grade 12 aggregate. It is therefore suggested that the Grade 12 aggregate be retained as a selection criterion for higher education studies.

Faktore wat grade voltooing van derdejaarsvlak Statistiek studente beïnvloed

Hierdie artikel poog om uit te vind watter faktore beïnvloed suksesvolle voltooiing (in die voorgeskrewe tydperk) van grade deur studente aan die Universiteit van die Weskaap (UWK) in Suid-Afrika. Die studente in hierdie studie het almal ten minste een semesterkursus in derdejaar Statistiek geslaag. Die studente se suksesvolle voltooiing is gemeet ten opsigte van Graad 12 gemiddeld, huistaal en Graad 12 Wiskunde resultate. Die studie volg 'n kwantitiewe benadering en gebruik historiese studente-uitslae. Faktore wat bydra tot of verhinder om suksesvolle voltooiing van studies te bepaal, is geanaliseer. Graad 12 gemiddeld was die mees betekenisvolle faktor om suksesvolle voltooiing te verseker. Daar word dus voorgestel dat die Graad 12 gemiddeld behoue moet bly in die nuwe skoolstelsel omdat dit 'n goeie voorspeller is vir naskoolse sukses.

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The Department of Education (DoE) restructured the higher education system of South Africa (Asmal 1999) in 2000 and introduced a new five-year national plan for higher education in 2001.[1] One of the priorities of this plan was to increase undergraduate output in order to ensure that the demand for high-level managerial and professional skills would be met (Dept of Education 2001a).

Throughput is defined as the number of undergraduates who complete their studies in the prescribed time (Cairncross 1999). From 2004, throughput has been one of the factors used to determine the funding of universities (Dept of Education 2001b). It is thus important for institutions of higher education to know their throughput.

The broader impact of improved throughput is that successful graduates enter the job market and promote the institution in their company profiles (as alumni). A larger group of students is also available for recruitment as postgraduates. Students who complete their studies in the prescribed time save on tuition fees, while the university gains by earning its subsidy more quickly and having more funds available for research and postgraduate studies.

Universities will have to take throughput seriously in terms of the diverse backgrounds from which students come and the duration of their courses. Recruitment agencies at universities should use throughput to improve their strategies as the time students take to complete their studies affects subsidies.

1. Context

The duration of a BSc degree in the Faculty of Science at the University of the Western Cape is three years, with a limit of five years for full-time study. Students have to obtain a minimum of 360 credits for the degree. To major in Statistics, a student either starts the subject in his/her first year and takes it through to the third-year level, or

1 This article originated as an MSc mini-thesis by A Latief, entitled "Throughput of UWC students who did at least one semester of third-year Statistics", submitted to the University of the Western Cape in October 2005.

starts at the second-year level and continues to the third-year level. The option of starting at the second-year level is only open to students who pass first-year level Mathematics (Science Faculty 2004).

For the period under consideration in this study, the entry requirements for students wishing to take Statistics at the University of the Western Cape were:

- a matriculation exemption certificate issued by the Matriculation Board of the South African Universities' Vice Chancellors' Association (SAUVCA);
- at least 40% at higher grade or 50% at standard grade in the matriculation Mathematics examination, and
- at least 40% at higher grade or 50% at standard grade in the matriculation examination in either Biology or Physical Science, or
- an examination recognised by the Joint Matriculation Board for this purpose.

In 1987 and 1990, respectively, the University of the Western Cape introduced Mathematical Statistics and Applied Statistics up to the third-year level, each course being divided into two semesters. Students had to pass both semesters of Mathematical Statistics or Applied Statistics at the third-year level in order to major in Statistics. The Applied Statistics course differed from the Mathematical Statistics course in that a student did not need a strong mathematical background to cope with its content. It contained theoretical elements but was designed to emphasise Statistics in its application. In 2002, the two courses were combined for reasons irrelevant to this study.

This study investigates the throughput of students who did at least one semester of third-year Statistics between 1975 and 2001. Successful throughput is defined as the completion of undergraduate studies in three consecutive years. The following factors relating to successful throughput were examined: Grade 12 aggregate, home language and Grade 12 Mathematics results. The reasons for selecting these factors will be discussed below.

2. Literature review

This study drew on the available literature for information on throughput as well as in determining the specific factors for consideration.

Nair (2002: 94) states that the government loses millions when students fail at higher education institutions, as well as spending millions on a schooling system which produces school-leavers who are underprepared for both higher education and the job market. With this in mind, Botha *et al* (2003: 132) write:

In the South African education system, students write a standardized, independently set, matriculation examination at the end of their school career (Grade 12). The results of this examination are used as the main criterion for admission to tertiary educational institutions. Subjects may be taken on two levels — higher grade and standard grade. A proposed new matriculation curriculum, however, will eliminate the difference between the standard and higher grades.

Fraser & Killen (2003) use the term "academic success" rather than throughput, to indicate that having students meet the assessment requirements of the programmes in which they have enrolled in the minimum time represents a greater success than if they have to repeat certain subjects. Bitzer & Troskie-De Bruin (2004: 119) argue that throughput should not be seen as the only criterion of quality or hallmark of high standards.

Lourens & Smit (2003) worked with students entering the Technikon Pretoria (which merged with the Technikon Northern Gauteng and the Technikon North-West to become the Tshwane University of Technology (TUT) at the beginning of the following year). They developed a model to predict success in the first year, using the following factors: student's age, province of matriculation, Grade 12 aggregate, Grade 12 symbol for English symbol (defined as adequate or inadequate), ethnic group, gender, campus (Pretoria versus satellite campuses), method of study (full-time versus part-time), financial aid (yes or no), marital status, type of accommodation (residential or not) and classification of educational subject matter (CESM, the major field of study).

Cairncross (1999) investigated the throughput and completion rates of fourth/final-year students in the Department of Human Ecology at the University of the Western Cape, defining completion rate as the number of students who completed their studies (Cairncross 1999: 3) and throughput as the number of students who completed their studies in the prescribed four years. She used students' Grade 12 results to categorise them as qualifying either for degree or diploma courses. The entrance requirements for degrees and diplomas differ, and Cairncross found that throughput rates for the degree course (which requires Grade 12 exemptions) were more than twice as high as those for the diploma course.

4. Factors selected for this study

4.1 Grade 12 aggregate

The Grade 12 aggregate score, which is the raw total of all the marks for all a student's school subjects, is viewed as an important factor in the context of throughput. Dawes *et al* (1999) defined a place-on-exam indicator by taking the individual Grade 12 aggregate score for all the students at a particular school and assigning the indicator to that rank score. They gave three reasons for using the place-on-exam. First, scores within the same school are compared, so students are not negatively affected by circumstances. Secondly, it can be used as a measure of relative merit for students without being influenced by the examination system or internal assessments at the school. Thirdly, it is easy to use and interpret. They also referred to a study done by Stoker et al (1986) which found Grade 12 aggregate score to be the strongest single predictor of success at university.

A study by Lourens & Smit (2003) at the Technikon Pretoria confirmed a relationship between Grade 12 aggregate and first-year success rate. They found that only 20.96% of first-years (1016 out of 4848) passed all their subjects first time around. No relationship existed for second- or third-year success. It was concluded that the Grade 12 aggregate and the major field of study played an important role in terms of students' first-year success.

4.2 Home language

The medium of instruction at the University of the Western Cape is English. Van Rooyen (2001) found that English as a home language was a significant predictor of the bridging-year mean percentage mark. Agar's (1991) study confirmed that disadvantaged students found it difficult to express themselves in English, with 75.3% of students in a bridging programme at the University of the Witwatersrand attributing their difficulties with academic actualisation to language barriers. Howie (2003), too, confirmed these views, showing that pupils' English proficiency was a strong predictor of success in Mathematics. Lourens & Smit (2003) divided students' symbols for English into two groups: "adequate" being at least a D on Higher Grade, a C on Standard Grade, or a B on Lower Grade, and any lower symbols being "inadequate".

The present study divided students into two groups — those with English as their home language and those with a non-English home language.

4.3 Grade 12 Mathematics

In their study, Botha *et al* (2003) used Grade 12 Mathematics symbols as a selection criterion for the Diploma in Veterinary Nursing (DVN) programme at the University of Pretoria. They used an adjusted mark defined as "Standard Grade minus 10%" and set the minimum of 40% of the adjusted mark for both Higher Grade and Standard Grade. They found a statistically significant difference to exist in this mark between the groups that passed and those that failed the first-year Veterinary Nursing course (Mann-Whitney non-parametric test, *p*-value = 0.0097). Grade 12 Mathematics results were thus seen to be related to the success or failure of veterinary nursing students at the tertiary level. Botha *et al* therefore recommended that students with marks above 57% for Grade 12 Mathematics be given preference for admission to veterinary nursing courses. They found no statistically significant relationship between the grade at which Mathematics had been studied (Higher Grade or Standard Grade) and success or failure at the first-year level (*chi*-square *p*-value = 0.1196).

5. Methodology

The study used historical student records and a quantitative approach. The cohorts of students under consideration were those who had completed their studies within three years versus those who took longer.

The population for the study consisted of all students who had completed at least one semester of either Mathematical Statistics or Applied Statistics at the third-year level. It did not matter if the student had failed the semester or repeated the semester in the next academic year. Students who registered for both semesters but did not attend class, did not write examinations, and had no course mark (obtained zero) for either semester were excluded. In total, 409 students met the criteria for inclusion.

Data for the study were historic (retrospective) and extracted internally from the University of the Western Cape's mainframe database (secondary source) without the need for a research instrument. The database is maintained by the University of the Western Cape's Information and Communication Services. All student data generated during normal academic enrolment, such as registration, student marks, year of completion, year of graduation, were captured and then stored in an ORACLE mainframe student database. With the permission of Information and Communication Services, any academic staff member can request information on his or her students for research purposes.

A common scale was created for the purposes of comparison between the Higher Grade and the Standard Grade. An A symbol on the Standard Grade was set as equivalent to a B symbol on the Higher Grade.

6. Limitations of the study

Academic years follow the calendar year. A student who completed his or her studies in three-and-a-half years was thus recorded as finishing in four years. Verification of data was not required as it was obtained from the University of the Western Cape's student database, which may be assumed to be correct. The study did not investigate the throughput of students who majored in Statistics because the

sample would then have become too small for modelling purposes. The sample was not representative of all students at University as it was limited to students majoring in Statistics. No data were available on socio-economic factors relating to the students, such as financial constraints, modes of transport to university, adequate study venues, and so forth. Nor does this study examine contributing factors (causal relationships).

7. Data analysis

The data requested were imported from a text file into Microsoft EXCEL. The Statistical Analysis System (SAS) software was used to transform the data into a format suitable for analysis. Analysed was performed using descriptive statistics, frequencies and cross tabulations. Associations between nominal and ordinal scaled variables were tested using chi-square. The Z-test was used to test for significance of effect size. All the *p*-values were tested at both 5% and 1% significance levels.

8. Results and discussion

Of the 409 students who enrolled from 1975 to 2001 and who completed at least one semester of Statistics at the third-year level, 86 (21.03%) completed their studies successfully in the prescribed time of three years. The other 323 (78.97%) either took more than three years to finish their studies, or dropped out, or were still registered on completion of the study. The average number of years taken was five years; the median four years.

Table 1 gives a summary of the *chi*-square *p*-values and the probability of throughput given a factor. A discussion of each factor in order of its significance for throughput follows.

8.1 Grade 12 aggregate

The throughput of students with a Grade 12 aggregate of 60% and above was 32% (43 out of 134), while that of students with a Grade 12 aggregate below 60% was 16% (43 out of 270), as shown in Table 1.

Table 1: Probability of throughput, given a factor

Factor	Row totals	Throughput 86 (21.03%)	Non-throughput 323 (78.97%)	*Chi*-aquare *p*-value
60% and above Grade 12 aggregate	134 (33.17%)	43 (32.09%)	91 (67.91%)	0.0002**
Below 60% Grade 12 aggregate	270 (66.83%)	43 (15.93%)	227 (84.07%)	
chi-square value = 13.9637	Note: Five missing values			
Effect size with respect to throughout: Z value = 3.7368; *p*-value < 0.0001**				
English home language	127 (31.05%)	36 (28.35%)	91 (71.65%)	0.0148*
Non-English home language	282 (68.95%)	50 (17.73%)	232 (82.27%)	
chi-square value = 5.9428	Note: Five missing values			
Effect size with respect to throughout: Z value = 2.4378; *p*-value < 0.0073**				
60% and above Grade 12 Mathematics	112 (27.79%)	32 (28.57%)	80 (71.43%)	0.0224*
Below 60% Grade 12 Mathematics	291 (72.21%)	53 (18.21%)	238 (81.79%)	
chi-square value = 5.2138	Note: Five missing values			
Effect size with respect to throughout: Z value = 2.2834; *p*-value < 0.0113**				

* Significant at a 5% level
** Significant at a 1% level

There is a significant difference between the two groups (Z value = 3.7368; *p*-value < 0.0001, with a 95% confidence interval of 8% to 25%). The Grade 12 aggregate was found to be the most significant factor related to throughput (*chi*-square value = 13.9637; *p*-value = 0.0002). This finding is also confirmed by the study conducted by Lourens & Smit (2003). The Grade 12 aggregate should be taken into consideration when selecting students, as higher Grade 12 aggregates relate to better throughput.

8.2 Home language

Home language is also a factor that relates to throughput (*chi*-square value = 5.9428; *p*-value = 0.0148). In all, 36 of the 127 English-speaking students (28.35%) were successful in completing their studies in the prescribed three years, compared to 50 of the 282 non-English-speaking students (17.73%). There was also a significant difference between the two groups (Z value = 2.4378; *p*-value = 0.0073, with a 95% confidence interval of 2% to 19%). This shows that if the medium of instruction is not the students' home language, fewer students will finish their studies within the prescribed time.

8.3 Grade 12 Mathematics

Throughput is also related to Grade 12 Mathematics results (*chi*-square value = 5.2138; *p*-value = 0.0224). In the group which scored 60% and above for Mathematics, the rate of successful throughput was 10% higher than in the below-60% group. There was also a significant difference between the two groups (Z value = 2.2834; *p*-value = 0.0113, with a 95% confidence interval of 1% to 19%). This means that Mathematics is a prerequisite for subjects where calculation and abstract thinking are necessary. The issue is: at what level should students have passed Mathematics to be selected for a science subject? This also has enrolment implications in that if the Mathematics prerequisite is set too high, enrolments in science will drop significantly. If the Mathematics prerequisite is set too low, more students with poor results (E symbols and below) will apply to study science (cf Tables 2 and 3).

Table 2: Mathematics symbols

Symbol	Higher grade count	Standard grade count
A	4	27
B	17	38
C	26	45
D	58	64
E	92	24
F	0	8

Table 3: Common scale symbols

Common scale	Frequency	Percentage
A	4	0.99
B	44	10.92
C	64	15.88
D	103	25.56
E	156	38.71
F	24	5.96
G	8	1.99

9. Conclusions

The Grade 12 aggregate was found to be the most significant factor distinguishing between students completing their studies in the prescribed time and students taking longer. The students in this study were divided into two groups: those with a Grade 12 aggregate of 60% or above, and those with a Grade 12 aggregate below 60%. The students in the former group had a significantly better throughput rate than those in the latter group. As the Grade 12 aggregate is thus an important factor relating to success at university, it it suggested

that it should be retained in the Further Education Training (FET) school system. (The new FET system measures a student's performance per subject on a scale of one to seven, without taking the aggregate into account.) It is recommended that universities be proactive in formulating new selection processes based on factors (such as Grade 12 aggregate) that relate to better throughput.

10. Future research

This study could be replicated to include all students at the University of the Western Cape. Future research could also investigate how financial, social and academic factors contribute to throughput. Another interesting question would be whether South Africa is producing enough graduates to meet the demands of the labour market in terms of specific skills? In other words, are the targets set by the Department of Education being met in terms of graduate output.

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