AN INVESTIGATION INTO STUDENT PERFORMANCE IN FIRST YEAR BIOLOGY AT THE UNIVERSITY OF JOHANNESBURG

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Abstract–The transformation in South African higher education in the past 20 years has been earmarked by mass participation (almost 80% growth). The changes in the school curriculum and increased pass rates at school level place the transition from school to university under the magnifying glass. Universities are confronted with underprepared entering students and are designing interventions and models to maintain standards and increase graduation numbers. The latest suggestion of a Flexible curriculum proposes that an additional year (i.e. four year BSc degree) is more beneficial and advantageous to many first year students as opposed to the three year BSc. degree option.

The Faculty of Science at the University of Johannesburg has been enrolling students in the BSc Life and Environmental Science programme (four year degree) which provides students with an opportunity to complete the one semester module in Biology (mainstream) over two semesters, in the four year offering. In the four year degree programme, students also start with the Biology module after completion of a generic first semester of bridging and not in the first semester when they enter university.

This research compares the success of students in the two streams (three year programme where students complete the Biology module in one semester to the four year programme where the students complete the one module of Biology over two semesters. Appropriate inferential statistics were employed in the comparison of the 2011 – 2013 cohorts (sample of 389 foundation and 457 mainstream entries). It will be shown that the interventions implemented in the four year degree can be considered as effective in developing the students' academic competency in biology relative to mainstream students.

Keywords: Flexible curriculum, Biology, Widening access, Academic success in Science programmes

1. INTRODUCTION AND PURPOSE

The transformation in South African higher education (HE) in the past 20 years has been marked by mass participation. Recent data provided by HESA (2014) and the CHE (2013) indicate, that the student enrolments have doubled post-1994. Higher education portrays higher accessibility and represents a more equitable student body with the representation by African enrolments growing from 15% in 1994 to 79% in 2010 (CHE, 2013, p.39). However, the Green Paper (DHET, 2012, p.10) raises challenges with the widening participation and lower graduation rates in Higher Education. In the field of Science Engineering and Technology (SET) the enrolment has increased by 4.4% (DHET, 2012, p.35) and the graduation rates have grown by 5.5% per year. The graduate output in the scarce skills such as SET is still insufficient to meet projections for economic development.

The CHE investigation (2013, p.43) indicates that the completion rate of BSc students is 23% and alarming when only 27% of students graduate within regulation time (three years to complete a three year degree). Many reasons can be found and parties blamed resulting in the current situation, but students have been failing first year at university long before 1994. The research question for this paper is: Does the extended Biology stream provide students with foundational provision to be successful in mainstream modules? The purpose is to provide evidence towards the increased enrolment in the extended modules.

2. LITERATURE REVIEW

2.1 Theoretical framework

This investigation will discuss four influences on the transition that first year students experience when they enter higher education. Failing first year has been discussed in academic papers, staff meetings and faculty offices for some time. Failing in science modules are almost expected and Bunting (2004, p.73-94) tracked the 2000 cohort and found that 41% dropped-out of university programmes. South Africa can no longer afford students dropping out with huge debts and no qualification to show for it. In a focus on first year science students, Jacobs (2010, p. 59-70) indicated the importance of the loss to the economy of students with scarce skills and highly subsidised programmes such as SET. Universities rely on fundamental sciences to be taught at school, by qualified teachers and that students would be able to graduate with a quality education.

2.2 Constant amendments to the school curriculum.

The South African secondary school curriculum has changed fundamentally since 1994 (Jacobs, 2010) with every new ministry bringing a new paradigm to the fragmented educational system. Politics changed in the past 20 years, school curriculums changed but poor and rural societies are still not being served with equipped schools and inspirational teaching. Prof. Jonathan Jansen (specialist educationalist) stated in the Beeld (31 December, 2003, p.8) that "… the South African school curricula, like national flags and anthems, are some of the most contested symbols of any social transition." According to the DoE (2008a, p.3), 2008 was a year of "…enormous significance for education in South Africa". The last Senior Certificate (SC) examinations were written in 2007, followed by the National Senior Certificate preceded by the National Curriculum Statement introduced in 2006 (RSA DoE, 2008b, p.3). Most recently the Curriculum and Assessment Policy Statement (CAPS) was implemented (DoE, 2011) and the first year cohort of 2015 have followed this curriculum.

The continuous changing of a national curriculum has created gaps in the knowledge and skill of learners exiting the school system (Jacobs, 2010; CHE, 2013) and teachers have needed to be trained with every new amendment. The decline in the pass rate of especially Physical and Life Science in Grade 12 emphasised the effects of these changes. In 2007, 68% of learners passed Biology (former Life Science subject) with more than 40%. The results were even worse in 2008, where only 39% of learners passed Life Science with more than 40%. An alarming trend is noted in the Physical Science results, in 2007, 69% of the learners passed Physical Science with more than 40% in comparison and only 28% in 2008 (DoE, 2007, p.27; DoE, 2008b, p.13). This is a very serious situation arising from curriculum changes Many reasons are be provided by officials to defend these pass rates.

2.3 An increase in shortage of qualified teachers

In a recent study conducted in the province of KwaZulu-Natal (South Africa) an estimated 8000 unqualified and under-qualified teachers were teaching in public schools (Bertram; Mthiyane, & Mukeredzi, 2013). According to Pandor (2004) there are 20 000 unqualified teachers in the whole of the South African Education system and a shortage of 6000 Mathematics teachers. A large number of unqualified and under-qualified in service teachers are holding back socio-economic development in the country according to Van Zyl, Els & Blignaut (2013). In 2009, there were 12,227,963 learners in 25 906 schools and with 413 067 teachers (1 teacher: 29.6 learners) (Jacobs, 2010). In these schools there were only 600 qualified Science teachers in 1997 (Naidoo & Levin, 1998, p.73) and in the past twelve years SA only delivered 5 000 teachers per year. Rademeyer (2009, p.395) calculated that SA requires to graduate 21 000 teachers annually.

2.4 Increased pass rates at school level.

Prof Johann Engelbrecht and colleagues at UP, investigated the Grade 12 performance in comparison to first year Mathematics in 2009 (Engelbrecht; Harding & Phiri, p.289). The results indicated that the 924 students had an average Grade 12 of 78% and the same group had an average of 35% for the first Mathematics test at university level. Data provided by the Department of Basic Education (DBE) showed that in 2010, 67.8% of the learners passed the examinations and this has increased to 78.2% in 2013. The graph below (figure 1) also demonstrates the increase in Mathematics and Physical Science passes.

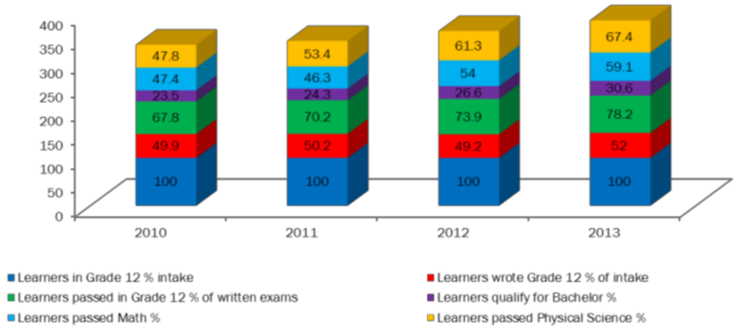

Figure 1: Nsc Results 2010-2013

Coupled with this Nel & Kistner (2009) and Jacobs (2010, p.67) found a distinct inflation of the original university application Grade 11 marks compared to the final NSC Grade12 marks. The research of Engelbrecht *et al* (2009, p. 297-299), Nel & Kistner (2009) and Jacobs (2010), therefore indicate that there is a significantly weak correlation between performance at university compared to Grade 12 NSC results. O'Connell (*Mail & Guardian*, December 2008, p.25) states that these students will battle to cope with the cognitive expectations required at higher education level.

2.5 Poorly resourced education environments and socio-economic backgrounds of South African students

The vast majority of modern day South African students come predominantly from marginalised and poorly resourced education environments and socio-economic backgrounds (CHE, 2013, p.58). This fact suggests that they would find higher learning challenging and, as a result, would most likely experience failure in the learning process (McGhie, 2012).

Taking into account the above facts, universities have been increasingly confronted with underprepared students entering the system and are challenged with bridging the gap from the school to university level at fundamental levels (writing, cognitive and conceptual deficits). Academics are pressured to increase throughput, deliver qualified graduates, and develop lifelong-learning attitudes and support poor and hungry students (CHE, 2013, p.66). Many academic support models have been followed (CHE, 2013, p.70-75) to maintain standards and increase graduation numbers. The latest suggestion of a Flexible curriculum (CHE, 2013) proposes that an additional year (i.e. four year BSc degree) is more beneficial and advantageous to accommodate underprepared students and lay a foundation for postgraduate studies.

3. PROPOSED FLEXIBLE CURRICULUM STRUCTURE FOR UNIVERSITIES

It has been proven that with more curricular space and time (Jacobs, 2010, p 258-259) underprepared students who enter HE can be moulded and supported to graduate within the minimum time. Nationally the higher education sector is addressing the "crisis" in HE with a proposal for undergraduate curriculum reform in South Africa: The case is made for a flexible curriculum structure, which has been published by the Council of Higher Education (CHE) in 2013. This proposal suggests the addition of an extra year to the norm for core undergraduate programmes, however, within a flexible structure that allows for the specific needs of the students ultimately to serve a diversity of students for improving student learning and overall performance (CHE, 2013, p.107). This new flexible curriculum aims to improve graduate output, enable better alignment of the curriculum with international conditions and standards and to provide equal and fair opportunities for the diverse array of South African students.

Final implementation of the proposal requires policy changes at national level, of which the main responsibility lies with the Department of Higher Education and Training (DHET). In addition, it is the responsibility of the higher education institutions to design and develop a curriculum which relates to the proposal (CHE, 2013).

3.1 University of Johannesburg: Four year degree model in Sciences

The University of Johannesburg (UJ), with specific emphasis on the Faculty of Science have already started to implement an extended curriculum in 2006 after the merger, in 2005, between the Rand Afrikaans University, Witwatersrand Technikon and Vista University (Soweto and East Rand campuses). The rationale for an extended curriculum was to provide a widening of access and wider participation for the new generation and diverse demography of students. The first intake into this programme was in 2004 and from then the programme has been refined to provide for a generic first semester from where students move into specific specialisation in the second semester. Due to the stigma of a name such as Extended the official programme has been changed to the B.Sc. Four Year Degree Programme since 2011.

The admission requirements of the four year curriculum are one APS score less than the mainstream three year degree for NSC Mathematics and Physical Science (e.g. 4 instead of 5). The four year degree has a flexible curriculum that extends the first year over two years with foundational support in language and computer competency. The first semester is a generic model where all the students do foundational content in mathematics, chemistry and physics (see figure 2)

TYPE	SEM 1	SEM 2	SEM 3	SEM 4	SEM 5	SEM 6	SEM 7	SEM 8
YR	YEAR 1		YEAR 2		YEAR 3		YEAR 4	
4 yr Ext BSc	MAT1AE1	MAT1AE2	MAT1AE3	MAT1B	MAJOR (i) 2A	MAJOR (i) 2B	MAJOR (i) 3A	MAJOR (i) 3B
	CEM1AE1	CEM1AE2	CEM1AE3	CEM1B				
	PHY1AE1	PHY1AE2	PHY1AE3	PHY1AE1				
	LANGUAGE FOR SCIENCE	LANGUAGE		BOT1B/ ZOO1B BIC1B/	MAJOR (ii) 2A	MAJOR (ii) 2B		
		BIO1AE1	BIO1AE2					
	COMPUTER COMPETENCE						MAJOR (ii) 3A	MAJOR (ii) 3B
		GGR1AE1	GGR1AE2	GGR1B	MAJOR (iii) 2A	MAJOR (iii) 2B		
			YEAR 1		YEAR 2		YEAR 3	
Main stream			MAT1A	MAT1B	MAJOR (i) 2A	MAJOR (i) 2B	MAJOR (i) 3A	MAJOR (i) 3B
			CEM1A	CEM1B				
			PHY1A	PHY1B ZOO1B			MAJOR (ii)	MAJOR (ii) 3B
			BIO1A	BIC1B BOT1B	MAJOR (ii) 2A	MAJOR (ii) 2B		

Figure 2: Extended BSc Programme (UJ)

After successful completion of the foundational modules, the students continue with these three modules (for another two semesters) and also have options to choose from Biology and or Geography in the Life and Environmental Sciences programme.

The class groups are smaller and the teaching staff is dedicated to ensure that students are provided with the fundamental content and skills to be successful in the years that follow on the first year. Students are also supported through more contact periods, help from tutors and additional support from learning centres and mentors. (UJ, 2014).

4. FOCUS OF THIS INVESTIGATION

This research paper focused on the comparative academic achievement of first-year Science Faculty students at the University of Johannesburg with specific emphasis on the biology modules. The main objective of this research was to compare the success of biology students in the three year programme, completing the Biology module in one semester with performance of students in the four year programme, completing the same Biology module in two semesters. Both these streams join in the same class in the second semester and the performance in this module is analysed. The hypothesis formulated suggests that the interventions implemented in the Four Year Degree programme can be considered as effective in developing the students' academic competency in biology relative to mainstream students.

5. METHODOLOGY

The academic achievement in the Biology modules (one semester for three year and two semesters for four year programme) as well modules that follow after the Biology when these students join in same modules. This is possible as the curricula of the two programmes are identical; the core obvious difference is the duration of the modules (two semesters in four year programme and one semester in the three year programme) and the outcomes are similar.

5.1. Participants and sampling

Purposive sampling was used when final results of students after completion of the one Biology module (mainstream) and final results of students after completion of the two semesters in the four year (extended programme) option for Biology 1A. Both these groups streamed into the second semester (1B) modules (they have the option of selecting one or more modules out of Botany 1B, Biochemistry1B and Zoology1B). Therefor students from the four year programme and three year programme will both enter the same 1B modules, attend the same classes and write the same exams and progress to the next year. The students in the three year programme will be first time entering students in the 1B module, but the students entering from the four year programme are already in their second year after completion of three semesters of foundational provision. Table 1 provides a demographic analysis of the participants.

Table 1: Demographic Analysis of Participants

Variable		3 Yr (Mainstream) (n=389)	4yr (Extended) (n=457)
Gender	F	61.9%	58.6%
	M	38.1%	41.4%
Ethnic Group	African	65.6%	85.3%
	Coloured	1.4%	1.5%
	Indian	5.8%	3.2%
	White	27.2%	10.0%
Gr 12 Profile	Ave APS	35.37	32.62
	Ave Life Sciences	79.34%	76.68%

5.2 Empirical data

In the dataset, over and above the comparison of the Biology results, there is also a comparison of the achievement in Botany, Biochemistry and Zoology, in the second semester (as mentioned above). Table 2 provides the lay-out of the analysis performed:

Table 2: Data Analysis

MODULES	3yr (mainstream)			4yr (extended)		
	2011	2012	2013	2011	2012	2013
Biology 1A10	X	X	X			
Biology 1AE1				X	X	
Biology 1AE2					X	X
Botany1B10		X	X		X	X
Biochemistry 1B10		X	X		X	X
Zoology 1B10		X	X		X	X

It is important to note that the three year degree Biology students and four year degree Biology students were combined and taught as a unit in Botany 1B, Biochemistry 1B and Zoology 1B modules respectively (no distinction between three year degree and four year degree students any more). This fact makes the results of the comparison extremely useful and meaningful to this research study.

A paired-samples t-test, including Pearson's product moment correlation coefficients, were conducted on the two pairs of first and second semester examination and final module marks, for the 846 students who enrolled for the different modules. Tables 3 and 4 below summarise the respective paired samples statistics, correlations and test findings in respect of the two sets of paired differences.

Table 3: Correlations

MODULE		BIO1A10	BIO1AE1/E2	BOT1A10	BIC1A10	ZOO1B10
BIO1A10	Pearson Correlation	1		.444**	.493**	.651**
	Sig. (2-tailed)			.000	.000	.000
	N	389	0	69	126	81
BIO1AE1/E2	Pearson Correlation		1	.678**	.537**	.464**
	Sig. (2-tailed)			.000	.000	.000
	N	0	457	78	92	53
BOT1B10	Pearson Correlation	.444**	.678**	1	.566**	.678**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	69	78	147	90	60
BIC1B10	Pearson Correlation	.493**	.537**	.566**	1	.614**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	126	92	90	218	72
ZOO1B10	Pearson Correlation	.651**	.464**	.678**	.614**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	81	53	60	72	134

** Correlation is significant at the 0.01 level (2-tailed).
a. Cannot be computed because at least one of the variables is constant.

Inspection of Table 3 shows the Pearson correlation for Biology 1A, Botany 1B (r = 0.444**); Biochemistry (r = 0.493**) and Zoology (r = 0.651**); are statistically significant (p < .001). Furthermore, Biology 1AE1/E2 ; Botany 1B (r = 0.678**); Biochemistry (r = 0.537**) and Zoology (r = 0.464**); have a statistically significant relationship (p < .001).

In Table 4 the statistics are shown. In the **Biology** modules (both programmes) are statistically significant (p < .001). The first semester **Biology** (mainstream) has as expected lower average of 53.46 (*SD* = 9.287) than the combined results for Biology (extended) average of 58.53 (*SD* = 7.613). In the second semester when students from both programmes enter the same modules the values are statistically significant (p < .001).

Table 4: Group Statistics

Module	Program	N	Mean	SD	Std. Error Mean
BIO1A10	MS	228	53.46	9.287	.615
	EXT	0[a]	.	.	.
BIO1A1E/2E	MS	0[a]	.	.	.
	EXT	324	58.53	7.613	.423
BOT1B10	MS	69	64.91	6.653	.801
	EXT	78	60.59	8.324	.942
BIC1B01	MS	126	66.94	9.179	.818
	EXT	92	62.66	7.398	.771
ZOO1B10	MS	81	58.80	9.285	1.032
	EXT	53	58.15	7.838	1.077

a. t cannot be computed because at least one of the groups is empty.

An independent samples t-test was conducted to enquire whether there is a significant difference between the performances of the mainstream and extended in the three modules in the second semester.

In Table 5 the independent samples t-test revealed a statistically significant difference between the mainstream and extended (*t* (143) = 3.496, (*p* = .001),

d =-801.505), with the marks of **Botany** mainstream (three year) (*M* = 61.91; *SD* = 6.653) better than the marks of the extended (four year) (*M* = 60.59; *SD* = 8.324).

The independent samples t-test revealed a statistically significant difference between the mainstream and extended (*t* (213) = 3.802, (*p* = .001), *d* =-801.505), with the marks of **Biochemistry** mainstream (three year) (*M* = 66.94; *SD* = 9.179) significantly better than the marks of the extended (four year) (*M* = 62.99; *SD* = 7.398).

In Table 5 the independent samples t-test revealed a statistically significant difference between the mainstream and extended (*t* (132) = .422, (*p* = .674),

d =.08), with the marks of **Zoology** mainstream (three year) (*M* = 58.80; *SD* = 9.285) equal to the marks of the extended (four year) (*M* = 58.15; *SD* = 7.838).

Table 5: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	**Sig. (2-tailed)**	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
BOT1A10	Equal variances assumed	3.178	.077	3.448	145	.001	4.323	1.254	1.845	6.801
	Equal variances not assumed			3.496	143.579	.001	4.323	1.237	1.879	6.768
BIC1A10	Equal variances assumed	4.562	.034	3.677	216	.000	4.273	1.162	1.983	6.564
	Equal variances not assumed			3.802	213.849	.000	4.273	1.124	2.058	6.489
ZOO1A10	Equal variances assumed	1.000	.319	.422	132	.674	.652	1.545	-2.404	3.707
	Equal variances not assumed			.437	123.598	.663	.652	1.491	-2.300	3.603

Levene's test indicated unequal variances for Botany (*F* = 3.178, *p* =.077, so degrees of freedom were adjusted from 145 to 143, and Biochemistry (*F* = 4.562, *p* =.034, so degrees of freedom were adjusted from 216 to 213).

The effect size was calculated using Cohen's d effect size values above (respectively *d* =-801.505 (Botany); *d* =0.52 (Biochemistry) and *d* =0.08 (Zoology)). The Cohen's d suggested a very large practical significance with regard to Botany, moderate to large practical significance for Biochemistry and small practical significance for Zoology.

5.3 Empirical synthesis

The empirical investigation generated the following noteworthy findings:

- **Access**: The extended programme provides access to more Black students and the widening of participation provides the students with a fair chance to pass the modules that follow.
- **Interventions**: The value added by smaller group and fundamental laboratory skills development of techniques and compulsory tutorials are two of the aspects that render foundational provision to extended Biology students, they are thus confident when required to apply in Botany, Biochemistry and Zoology.

6. CONCLUSION

Based upon students' ultra-positive lived experiences and their significantly (statistically and practically) achievement in the second semester modules (Botany, Biochemistry and Zoology), the influence of the new teaching and learning strategy on student learning in Biology cannot be ignored or overemphasised. At the heart of the project's success lies a collaborative and constructive interplay between students, staff and support structures (tutors, technology, adapted curriculum, to name but a few). This paper provided evidence of two streams of students entering the HE system with different school profiles and provided with an equal chance of passing mainstream modules after structured interventions have been applied.

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