THE RELATIONSHIP BETWEEN SELECTED GRADE 12 SUBJECTS AND ACADEMIC ACHIEVEMENT OF FIRST YEAR LIFE SCIENCE EDUCATION STUDENTS

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ABSTRACT – This paper reports on the challenge when future Life Sciences enter university Life Science teacher's modules meeting the Grade 12 admission requirements but perceived to have a gap in fundamental content knowledge and skills. These are the future teachers and the assumption is that they enter with sound knowledge acquired at school and sufficient to serve as foundations to pass the first semester in Life Sciences module. As admission requirements the universities need to ensure that the entering students have probability to graduate and are sent into the community as able teachers with in-depth content knowledge. This study examines the success rate of 479 first year Life Science students in the B.Ed programme in the first semester, with the Grade 12 Mathematics, Life Science and Physical Science results. The findings of the research suggest that students need prior knowledge and skills acquired at school level and the dataset indicates that there is predictive value in the National Senior Certificate (Grade 12) results for success at university but that Physical Science has a greater predictive value. This research will be applied as a motivation to change the current entry requirements for first year Life Science modules in order to increase the quality of future Life Science teachers.

Keywords: Life Science; Success rate; Education; Admission requirements.

1. INTRODUCTION AND PURPOSE

The South African media is constantly broadcasting the poor performance of school learners in the country (Jacobs, 2010) and the Department of Basic Education (DBE) acknowledges the need for training and development of quality teachers (DBE, 2012) to enhance the preparedness of the learners. The Faculty of Science at the University of Johannesburg offers the content modules in Life Sciences (previously known as Biology) as components in the BEd qualification in the Faculty of Education. Training of teachers in the Further Education and Training (FET) band prepare teachers to teach Grade 10, 11 and 12 learners with six modules as components of the BEd qualification. The six modules (two modules each in the first, second and third year of studies) were designed and aligned with the Curriculum and Assessment Policy Statement (CAPS) and provide content knowledge in order for teachers to be well prepared to teach Life Sciences at secondary school. Graduates enter the teaching profession and teach Life Sciences and hopefully they inspire learners study Life Sciences or other related disciplines after leaving school.

The overarching long term objective in designing these modules is to achieve better Grade 12 Life Science performance and ultimately to cultivate an interest for future Life Science students at higher education level. Therefore, lecturers should take care that the educator graduates are qualified and able to teach Life Sciences with great confidence, sound content knowledge and skilled in laboratory practices. The university sector is very aware that high-quality undergraduate education is central to recruiting post-graduate students and paves the way to the success of all life scientists (Pelaez, Anderson and Postlethwait, 2015).

When prospective students decide to further their studies, they have to carefully consider many facts such as their own ability and interest in the field. A student interested in becoming a Life Science educator at Grade 10-12 level must have obtained a National Senior Certificate (NSC) with endorsement (providing admission to university studies). Furthermore, the applicant must have passed English, Mathematics, Physical Sciences or Life Sciences with an Admission Point Score (APS) of 4 (minimum 50%). At the University of Johannesburg the student may study Life Sciences without ever having taken it at secondary school level but at least passing Physical Sciences in grade 12. Although many students meet the official admission requirements, it is also important to be interested, motivated and enjoy the field in which you will spend most of your waking hours at work, as teaching is a professional activity.

Universities in South Africa (SA) have admission requirements (UJ, Faculty of Science 2011 - 2014) which acts as a determinant of prior success and knowledge. It is assumed that these minimum requirements would have some predictive value to ensure that students are able to pass the modules as specified. This paper investigates this predicative value and the research question that this inquiry attempts to answer is stated as follows: What is the relationship between admission requirements and academic achievement of Life Science education students of their first year at university?

The purpose is to provide evidence of specific prior subject knowledge that a student will need to pass the Life science modules at university. Four different Grade 12 subjects (English, Mathematics, Physical Science and Life Sciences) results were compared with the results of the first year Life Sciences module for the FET students to provide insight of which subjects could contribute towards university achievement in Life Sciences. The result of the comparison could inform setting admission requirements for entry into a Bachelor's degree in Education with Life Science as a major.

2. LITERATURE REVIEW

2.1. Theoretical framework

There is some controversy about the influence of admission requirements on academic performance at university level. In teacher training a different perspective is placed on performance of specifically first year students. The expert scientist is not necessarily a good science teacher however an expert science teacher will be able to present knowledge in such a way that students or school learners' can develop their own understanding. Lee Shulman (1986) refers to this expertise as pedagogical content knowledge (PCK) and states that excellent teachers will have expert content knowledge and PCK. These expert teachers will have effective strategies to work with learners and therefore cultivate the scientists of the future. The authors are making the assumption that students in teachers training programmes should have sound content knowledge and skills set when they exit the secondary schooling system and therefore have good school results as evident in their admission scores.

The authors of this paper are of the opinion that the admission requirements do influence the foundation from where university context start as pre-service education of Life Science teachers, especially in the current South African school context, and furthermore influence their own teaching practices, study incentive and will assist to shape their role as teachers.

2.1.1. The vast gap between school knowledge and required first year Life Science knowledge

There exists a gap between in the NSC document (prescribed curriculum) to what learners really know as been found by university lecturers when they test entering students at the beginning of the academic year (Jacobs & Pretorius, 2015). University lecturers have the perception that they can start content where schools left off and expect students to have fundamental knowledge, in Life Science and Physical Science acquired at secondary school (CHE, 2013). Williamson, Pretorius and

Jacobs (2014) found that this gap is mainly caused by constant amendments to the school curriculum, an increase in the shortage of qualified teachers and the poorly resourced education environments and socio-economic backgrounds of South African students.

The American Association for the Advancement of Science (2011) explains the fact that any Science is a complex commodity to understand because of the emphasis placed on integrating, organizing, synthesizing, and analysing of content. To understand and develop new concepts, skills and knowledge, relies on prior skills and knowledge (Herman, Aschbacher and Winters, 1992; Tobias and Everson, 1996). In this context the prior skills and knowledge are obtained at Secondary School level. These students need to demonstrate the ability to retain and assess their prior knowledge and skills, especially in modules which consist of a multitude of volumes of new knowledge and skills as in the case of Life Sciences (UJ, 2015). When students are able to accurately monitor their knowledge they should be able to focus their efforts on studying content not yet understood (Tobias and Everson, 1996). However, students who did not completely understand at a lower/primary level and who cannot utilise their prior knowledge accurately may not devote effort to studying (Ehrlinger et.al. 2008) or may devote effort to studying content already understood while neglecting content that is not (Tobias and Everson, 1996). If students are unable to monitor or evaluate their own learning by being able to distinguish between what they do and do not know, they cannot envisage metacognitive activities (Tobias and Everson, 2002). Envisaging students' metacognitive skills is fundamental for enhancing student understanding of concepts or connections between concepts (Tanner and Allen, 2005). Therefore, if a student wants to study Life Science as a major, the first year student should have already mastered some metacognitive skills or the students will set themselves up for failure.

In order to close the gap, tertiary institutions have to intervene by adjusting the admission requirements to specialise in life science teaching and adapt the current curriculum to appropriately equip the student for the teaching profession.

2.1.2. Increased NSC pass rate since 2008

There remains a pertinent uneasiness about the increased pass rates at schools in South Africa since 2008 and specifically the NSC grade 12 results provided by the Department of Basic Education (DBE) showed that in 2010 67.8% of the learners passed the NSC examinations and this has increased to 78.2% in 2013. Engelbrecht, Harding and Phiri (2009), did a study using two universities of South Africa which showed a considerable increase in the Grade 12 pass rate of 2009 compared to 2007. This study shows a significant increase in the number of students with marks higher than the 70%. This is indeed a positive message for the DBE, however Engelbrecht, et al. (2009) conclude that the Grade 12 results of 2009 showed a significant paradigm shift to the left (less than 50%) in these students first year performance, specifically focussing on Mathematics. Coupled with this Nel and Kistner (2009) and Jacobs (2010) found a distinct inflation of the original university application Grade 11 marks compared to the final NSC Grade12 marks. These authors with the research of Engelbrecht et al. (2009) indicate that there is significantly weak correlation between performances at university when compared to Grade 12. The question thus arises: "Can we apply the Grade 12 marks as a benchmark for admission into a tertiary institution and more specifically into a scientific field, or should higher education institutions increase the admission requirements to accommodate the inflation of Grade 12 NSC marks or consider the National Benchmark Test (NBT) as an additional predictive criteria for admission?"

2.1.3. Discourse of Science

Life Science consists of a specific coding or discourse which can be referred to as scientific vocabulary or "Language of Science". Firstly students generally find it difficult to understand scientific concepts and processes because of language barriers (most students are non-English native tongue) (UJ, Faculty of Science 2015b). Therefore, they also find it difficult to write, spell and read words and paraphrase. Secondly, if a student has never been required to use written "Science Language" and the spoken terminology sounds like a foreign language they tend to experience greater challenges at tertiary level. Language is an expression of what you know and could provide obstacles for students who enrol to study Life Science at a tertiary institution.

The following definitions are taken from Heath Biology by McLaren and Rotundo (1989) as examples of the complexity of language as expression of Life Sciences. For example a base according to the Oxford dictionary of Biology's (2008) definition, is a compound that reacts with an acid to give water and a salt, the English Heinemann dictionary' (1995) definition of a base, is the following: The lowest or bottom part: the base of a cliff; the base of a lamp. The scientific definition of an adaptation states that an adaptation is a structure or behaviour that allows survival in a particular environment, The English dictionary defines it as a play which is an adaptation of a short novel. The above mentioned emphasise the importance of scientific discourse in mastering Life Sciences, which ensures professionalism as a Life Science educator.

2.2. Focus of this investigation

This research paper focussed on the comparative academic achievement of future Life Science teachers, in the first-year entering the Life Science module, with Grade 12 NSC results as admission requirements. The main objective of this research is to compare the success of Life Science students in the B.Ed programme (one module) of the University of Johannesburg, using the 2012 – 2014 cohorts, with the contribution of the admission requirements (Grade 12 Mathematics, Life Sciences, Physical Sciences and English).

3. METHODOLOGY

The academic records of 479 first year students in three cohorts were investigated and analysed to determine the relationship between the academic achievements of the students in Life Science 1A (module in the first semester in the first year) and the admission requirements that gained them entrance into the module. The study was performed at the University of Johannesburg, with 2012 – 2014 cohorts and compared results in four Grade 12 subjects (Mathematics, English, Physical Sciences and Life Sciences) as formally listed as admission requirements to gain entry into the module. The categorical variables were examined by means of the Pearson chi-square test of independence. A statistically significant ($p < 0.05$) chi-square indicate a relationship between the Grade 12 variable (Mathematics, English, Physical Sciences and Life Sciences) and success in Life Sciences at university level.

The relationships between the performance in Grade 12 (subjects as listed above) and student success in Life Sciences (1A) were examined by means of one-way ANOVA's, where the Grade 12 performance (in the four subjects) serves as the continuous variable and Life Sciences 1A success serves as the grouping variable. The hierarchical regression analysis determine the R^2 change to indicate how much additional variance is explained by the predictor (Grade 12 admission requirements) in addition to the first predictor (Grade 12 Mathematics) in the regression equation.

The order of entry of variables in the hierarchical analyses was as follows:
Step 1: Mathematics performance in Grade 12;
Step 2: English performance in Grade 12;
Step 3: Physical Science performance in Grade 12; and
Step 4: Life Sciences performance in Grade 12.
At each step of the analysis a R^2-statistic was computed, which indicates the proportion of variance in the dependent variable that is explained by the independent variable(s) included at the step.

The difference between the R^2 at Step 1 and the R^2 at Step 2, Step 3 and Step 4 indicates the amount of variance uniquely explained by the Life Sciences, after taking into account the role of each subject. A statistically significant ($p < 0.05$), change in R^2 from Step 1 to Step 2, Step 3 and 4 signifies that the Grade 12 subjects do or don't have predictive value for the performance in Life Sciences 1A in the B.Ed first year teachers programme.

The following null-hypothesis and alternative hypothesis are stated:
H_0: There is no association between the students' marks in Mathematics, English, Life Sciences and Physical Sciences in Grade 12 and their Life Sciences 1A in their first year of study.

H_A: There is an association between the students' marks in Mathematics, English, Life Sciences and Physical Sciences in Grade 12 and their Life Sciences 1A in their first year of study.

3.1. Participants and sampling

Purposive sampling was used with students completing the one Life Science 1A module at the University of Johannesburg and entered with the suitable admission requirements of Grade 12 results after completion of secondary school level. Three cohorts were followed (2012, 2013 and 2014) and Table 1 provides a summary of the number of students per subject group that formed part of the sample of the participants.

Table 1. Sample size in different subjects and cohorts

	Grade 12 NSC subjects (Variables)			
Cohort	**English N**	**Mathematics N**	**Life Sciences N**	**Physical Sciences N**
2012	**243**	**177**	**243**	**173**
2013	**148**	**124**	**135**	**132**
2014	**88**	**83**	**82**	**87**
Total	**479**	**384**	**460**	**392**

3.2. Empirical data

In the dataset, the association between the admission requirements (Grade 12 subjects) and their Life Sciences 1A, a first semester module in their first year, are investigated.

A cross tabulation was performed and the chi-square test of independence was conducted on the three cohorts and in the four Grade 12 subject groups to determine association. The chi-square test tests for the existence of a relationship between the variables. Secondly, the hierarchical regression analysis was conducted on the whole sample to determine the R^2 change to indicate how much additional variance is explained by the predictor (Grade 12 admission requirements) in addition to the first predictor in the regression equation.

In Table 2 the chi-square test statistics and the strength of the relationship is indicated with the Kendall's tau-b symmetric measures, as shown in the table. The Kendall's tau-b shows the amount of variation explained by the independent variable (in this case the four school subjects).

Table 2. Chi-square and Kendalls' tau-b statistics

Cohort	Gr 12 Subj	Chi-Square Tests				Symmetric Measures	
		N	Pearson Chi-Square Value	df	Asymp.Syg. (2-sided)	Kendall's tau-b	Approx.Syg.
2012	Mat	177	5.100	4	.277	.136	.049
	Eng	243	12.101	4	.017	.151	.010
	PSc	173	15.259	4	.004	.247	.000
	LSc	243	29.241	4	.000	.282	.000

2013	Mat	124	4.255	4	.373	.161	.041
	Eng	148	5.877	4	.209	.160	.052
	PSc	132	22.500	4	.000	.338	.000
	LSc	135	22.375	4	.000	.291	.000
2014	Mat	83	.795	2	.672	.067	.522
	Eng	88	.401	2	.818	-.026	.800
	PSc	87	8.117	2	.017	.298	.007
	LSc	82	5.500	2	.064	.239	.024

For the **2012** cohort the chi-square test was performed and no significant relationship was found between **Grade 12 Mathematics** and **Life Science 1A**: X^2 (4, *N* = 177) = *5.100*, *p* = .277. The tau-b (.136) is between +0.05 - +0.20 which is a weak positive association and a significant relationship.

For the **2013** cohort the chi-square test was performed and no significant relationship was found between **Grade 12 Mathematics** and **Life Science 1A**: X^2 (4, *N* = 124) = *4.255*, *p* = .373. The tau-b (.161) is between +0.05 - +0.20 which is a weak positive association and a significant relationship.

For the **2014** cohort the chi-square test was performed and no significant relationship was found between **Grade 12 Mathematics** and **Life Science 1A**: X^2 (2, *N* = 83) =*.795*, *p* = .672. The tau-b (.067) is between +0.05 - +0.20 which is a weak positive association and not a significant relationship.

In the three findings above no difference was found between the students' marks in Mathematics in Grade 12 and their Life Sciences 1A in their first year of study as students performed as expected adhering to the admission requirement.

For the **2012** cohort the chi-square test was performed and a significant relationship was found between **Grade 12 English** and **Life Science 1A**: X^2 (4, *N* = 243) = *12.101*, *p* = .017. The tau-b (.151) is between +0.05 - +0.20 which is a weak positive association and a significant relationship.

For the **2013** cohort the chi-square test was performed and no significant relationship was found between **Grade 12 English** and **Life Science 1A**: X^2 (4, *N* = 148) = *5.877*, *p* = .209. The tau-b (.160) is between +0.05 - +0.20 which is a weak positive association and not significant relationship.

For the **2014** cohort the chi-square test was performed and no significant relationship was found between **Grade 12 English** and **Life Science** 1A: X^2 (2, *N* = 88) =*.401*, *p* = .818. The tau-b (-.026) is between -0.40 - -0.20 which is a moderate weak negative association and not a significant relationship.

In the three findings above it was only the 2012 cohort that was found to indicate a significant difference between the students' marks in English in Grade 12 and their Life Sciences 1A in their first year of study.

For the **2012** cohort the chi-square test was performed and a significant relationship was found between **Grade 12 Physical Science** and **Life Science 1A**: X^2 (4, *N* = 173) = *15.259*, *p* = .004. The tau-b (.247) is between -0.05 - +0.05 which is no association and a significant relationship.

For the **2013** cohort the chi-square test was performed and a significant relationship was found between **Grade 12 Physical Science** and **Life Science 1A**: X^2 (4, *N* = 132) = *22.500*, *p* = .000. The tau-b (.338) is -0.05 - +0.05 which is no association and a significant relationship.

For the **2014** cohort the chi-square test was performed and a significant relationship was found between **Grade 12 Physical Science** and **Life Science 1A***:* X^2 (2, *N* = 87) = *8.117*, *p* = .017. The tau-b (+.298) is between +0.20 - +0.40 which is a moderate positive association and a significant relationship.

In the three findings above it was found that all three cohorts indicated significant relationships between the students' marks in Physical Science in Grade 12 and their Life Sciences 1A in their first year of study.

For the **2012** cohort the chi-square test was performed and a significant relationship was found between **Grade 12 Life Sciences** and **Life Science 1A***:* X^2 (4, *N* = 243) = *29.241*, *p* = .000. The tau-b (.282) is between +0.20 - +0.40 which is a moderate positive association and a significant relationship.

For the **2013** cohort the chi-square test was performed and a significant relationship was found between **Grade 12 Life Sciences** and **Life Science 1A***:* X^2 (4, *N* = 135) = *22.375*, *p* = .000. The tau-b (.291) is between +0.20 - +0.40 which is a moderate positive association and a significant relationship

For the **2014** cohort the chi-square test was performed and no significant relationship was found between **Grade 12 Life Sciences** and **Life Science 1A***:* X^2 (2, *N* = 82) = *5.500*, *p* = .064. The tau-b (+.239) is between +0.20 - +0.40 which is a moderate positive association and not a significant relationship.

In the three findings above it was found that the 2012 and 2013 cohorts showed significant relationships between the students' marks in Life Sciences in Grade 12 and their Life Sciences 1A in their first year of study.

To examine the contribution of the school Mathematics, English, Physical Science and Life Sciences in the prediction of achievement in the Life Sciences 1A module, a hierarchical multiple regression analyses were performed with all three cohorts. The hierarchical analysis proceeded in four steps, where the Grade 12 results of the four subjects were entered after each other to allow for an examination of the predictive power of the Grade 12 subjects. The relative contribution of the subjects at Grade 12 level toward the prediction of Life Sciences 1A achievement, as evaluated through examination of the change in the proportion of variance in Life Sciences performance.

On inspection of Table 3 the hierarchical regression analysis on the whole sample are shown to indicate the R^2 change showing the variance explained by the predictors (Grade 12 admission requirements).

Table 3. Proportion of variance in Life Science 1A explained by Grade 12 subjects (Cohorts 2012-2014)

Model	R	R^2	Adjusted R^2	SE	Change Statistics				
					ΔR^2	ΔF	$df1$	$df2$	Δp
1	.297[a]	.088	.086	11.178	.088	33.393	1	345	.000
2	.413[b]	.170	.166	10.678	.082	34.094	1	344	.000
3	.522[c]	.273	.266	10.013	.102	48.218	1	343	.000
4	.549[d]	.301	.293	9.828	.029	14.008	1	342	.000

a. Predictors: (Constant), Gr12 Math
b. Predictors: (Constant), Gr12 Math, Gr12 Eng
c. Predictors: (Constant), Gr12 Math, Gr12 Eng, Gr12 PHY
d. Predictors: (Constant), Gr12 Math, Gr12 Eng, Gr12 PHY, Gr12 LFSC

Table 3 shows that:

- Grade 12 **Mathematics** on its own accounted for 8.6% of the variance in Life Sciences 1A (ΔR^2 = 0.086; F = 33.393; df = 1, 345; $p < 0.001$),
- Grade 12 **English** with **Mathematics** accounted for 16.6% of the variance in Life Sciences 1A (ΔR^2 = 0.166; F = 34.094; df = 1, 344; $p < 0.001$),
- **Physical Sciences** with **Mathematics** and **English** accounted for 26.6% of the variance in Life Sciences 1A
  (ΔR^2 = 0.266; F = 48.218; df = 1, 343; $p < 0.001$) and
- **Life Sciences** at Grade 12 level, with the other three Grade 12 subjects accounted for 29.3% of the variance in Life Sciences 1A
  (ΔR^2 = 0.293; F = 14.008; df = 1, 342; $p < 0.001$).

  Thus the greatest contribution towards **Life Sciences 1A** comes from Physical Sciences (10.6%), with Mathematics (8.6%), English (7.4%) and Life Sciences (2.7%) that contributed significantly towards explanation of Life Science 1A performance and jointly accounted for 29.3% of the total variance in Life Sciences 1A.

3.3 Empirical synthesis

The empirical investigation generated the following noteworthy findings:

- **Admission requirements:** The Physical Sciences admission requirements have greater influence in Life Sciences results and could be ascribed to the focus on Biochemistry forming a substantial component in the Life Science module.

- **Mathematics and Physical Sciences in Grade 12:** These subjects provide problem solving skills and scientific methodology integrated into Life Science curriculum.

4. CONCLUSION

The trends identified indicate that Secondary School Physical Sciences contribute greatly to the success rate of first year Life Science Education students. The early identification of current at-risk Life Science students, based mainly on Grade 12 Mathematics and Physical Sciences performance, should preferably be placed in small tutorial groups to bridge the previously mentioned gap between school and university. Special attention should be provided to these students with regard to Biochemical content, since the Life Science university curriculum starts with complex biochemical molecules and processes. Thus, it is recommended that all students that enrol for Life Science should at least have an APS Physical Science score of 5.

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