Mathematics 1 Performance at a University of Technology Versus English Proficiency

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Abstract

Many tertiary institutions in South Africa offer intervention programmes that are intended to help first-year tertiary students, whose first language is not English (second-language students) , cope with language needs of their academic studies. Some of the institutions use grade 12 English results as a criterion for admission into the English intervention programme. The targets for the intervention in some of these institutions are those students whose grade 12 English results are less than 49%. Other institutions in South Africa make it compulsory for all first-year students to do the communicative English. The paper questions whether proficiency in English as defined in terms of grade 12 English marks is a predictor of performance in the students' tertiary academic courses, specifically in mathematics. Two categories of students of similar grade 12 mathematical ability are compared in terms of performance in mathematics 1 academic course. One category consists of students with a predetermined grade 12 mathematics ability, whose grade 12 English marks are relatively good (60%+). The other group consists of students with the same grade 12 mathematics ability, but whose grade 12 English marks are relatively poor (49%-). The paper found that there is no statistical difference between the two groups, meaning that proficiency in English as defined by grade 12 English results is not a predictor of performance in mathematics 1.

1. Introduction

The intention of the South African English-medium tertiary institutions that offer English improvement programmes for first-year students is mainly to facilitate the students' grasp of their academic courses. The proponents of the intervention are sometimes persuaded by consideration of the fact that, for instance, mathematics students are unable to answer mathematics application problems since the applications are presented as English-word problems. Consequently, such proponents' focus of intervention is usually on improvement of communicative aspect of English. However, other people may argue that English language proficiency is not enough as the solution to the mathematics application problems. Some of the reasons given are that some mathematical terms do not have the same meanings as their English counterparts. Terms like 'differentiation', 'integration' come into mind. This raises questions about whether there should be differentiated English intervention programmes – one for science students and the other for non-science students. Currently, the language intervention of most tertiary institutions in South Africa is that of generic English, done by all qualifying students.

The focus of this paper was to determine if the intervention was effective. The investigation in this paper zoomed on the institutions using grade 12 English results to determine the admission to the programme. By using low grade 12 English marks as a criterion of admission of the candidates to the intervention programme, the underlying assumption was that the candidates with poor grade 12 English marks would encounter language problems

in their academic studies (as opposed to those with good grade 12 English marks), which could negatively impact on their first-year academic performance. This was what this paper questioned. Would students with high grade 12 English marks do better in mathematics 1 results than those whose grade 12 English marks were low? In other words, is grade 12 English performance a predictor of performance in first-year mathematics? The study focused on the English second-language students, who are the main target of the intervention programmes in many South African tertiary institutions. In other words, this paper was looking at the relationship between English proficiency as defined by grade 12 English results and achievement in first-year mathematics.

2. Aim of the research and significance of the study

2.1. Aims

The central aim of the study was to investigate the impact of grade 12 English marks on the performance of tertiary second-language students in their first-year mathematics. Hence, the research intended to investigate:

2.1.1. if there was statistical difference in maths 1 performance between two groups of students who obtained symbol A in grade 12 mathematics, with one group having obtained a relatively high symbol C (60%+) in grade 12 English and the other having obtained a relatively low symbol E (49%-) in grade 12 English;

2.1.2. if there was statistical difference in maths 1 performance between two groups of students who obtained symbol B in grade 12 mathematics, with one group having obtained symbol C (60% or more) in grade 12 English and the other having obtained symbol E (49% or less) in grade 12 English;

2.1.3. if there was statistical difference in maths 1 performance between two groups of students who obtained symbol C in grade 12 mathematics, with one group having obtained symbol C (60% or more) in grade 12 English and the other having obtained symbol E (49% or less) in grade 12 English;

2.1.4. if there was statistical difference in maths 1 performance between two groups of students who obtained symbol D in grade 12 mathematics, with one group having obtained symbol C (60% or more) in grade 12 English and the other having obtained symbol E (49% or less) in grade 12 English;

2.2. Significance of the study

2.2.1. If it can be established that grade 12 English mark was a predictor of mathematics 1 performance, then not only would it justify the practice of those institutions using criterion of grade 12 admission to the intervention programme, but it would define the English scope of such intervention – to cover a minimum of 60% of grade 12 English.

2.2.2. If it could established that grade 12 English mark was not a predictor of mathematics 1 performance, then it would open up a research scope of determining the impact of allowing all first-year students to do a generic post grade 12 English intervention. Other tertiary institutions in South Africa currently allow all first-years to do compulsory generic English in order to improve on their English.

2.2.3. If it could be established that grade 12 English mark was not a predictor of mathematics 1 performance, then it would open up a research scope of establishing the impact of differentiated English intervention, one for the sciences and the other one for humanities.

3. Theoretical framework

Philosophical aspect of the study

The philosophical foundation of the quantitative study was premised on the positivist epistemology. Epistemology is the meaning ascribed to knowledge and its creation (Darlaston-Jones, 2007:25; Summer and Tribe, 2004:3). Knowledge that develops through a postpositivist lens is based on careful observation and measurement of the objective reality that exists 'out there' in the world (Creswell 2003:6; Summer and Tribe 2004:4). The 'goal of the academic enquiry' is, from the positivist perspective, 'acquisition of the truth' (Summer & Tribe 2004:4). In attempting to establish the impact of grade 12 English results on maths 1 performance at a University of Technology in South Africa, there was an underlying assumption that the intervention would somehow impact on maths 1 learning.

3. Literature survey

Studies have been conducted to better understand the relationship between English language proficiency and mathematics learning. The majority of these studies were conducted at an elementary level (for example, Clarkson, 1991; Setati & Adler, 2001). Only a few of the studies were conducted at the senior secondary or tertiary levels (Gerber et al., 2005; Neville-Barton & Barton, 2005). Elder (1993) and Graham (1987) estimated the variability in academic performance due to English language ability was up to 10 percent for university students, and that it is higher for humanities and social science subjects in comparison with mathematics or science subjects. However, Barton and Neville-Barton (2003) suggested that the disadvantage due to language was possibly as high in mathematics as in other subjects (Neville-Barton & Barton, 2005).

Barton and Neville-Barton (2005) described one of the studies relating to impact of language on performance. This study involved 40 Years 12 and 13 Chinese Mandarin-speaking students. The project had a bilingual native Mandarin-speaking teacher, Jushi Hu, who was able to write parallel tests in Mandarin and English. These tests were administered in two sittings seven weeks apart. At each sitting half the students did the English and half the Mandarin version, swapping over in the second test. The analysis focused on comparing students' performance on the Mandarin and English versions of the mathematics test. Group interviews were conducted to gather further insight into the test responses.

The study indicated that these students experienced, on average, a 15 percent disadvantage in overall performance in the English test compared to their performance in the Mandarin test. Barton and Neville-Bartons' (2005) other studies showed that the disadvantage experienced by students whose first language was not English (EAL students) was higher than expected, and was severe for those students with lower English proficiency. All five studies offered quantitative or qualitative evidence that EAL students suffer a disadvantage in mathematics learning due to language difficulties. The extent of this disadvantage was measured as 12 percent and 15 percent in two of the studies, and this corroborates with earlier work by Barton and Neville-Barton at first year university level. Some interview data, along with the experiences of the teacher/researchers, indicate that students having difficulty with language "switch off" in class, relying on texts or handouts. They tend to focus on procedures and approach mathematical problems in tests by trying to recognise a suitable procedure without trying to understand the context. For example, the word "less" may produce a response of "subtract" when this is inappropriate. Language difficulties also

seem to limit students' mathematical solving techniques; for example, such students have difficulty drawing a diagram and are restricted to symbolic mode.

Gerber et al (2005:17 - 18) looked at the impact of Afrikaans on mathematics performance. Mathematics performance of Afrikaans first-language students doing mathematics in Afrikaans was compared with mathematics performance of Afrikaans first-language students doing mathematics in English. There was a statistically significant difference in the performance of the Afrikaans students attending Afrikaans lectures and the Afrikaans students attending English lectures, with the former outperforming the latter. However, Gerber et al (2005) found the difference to be marginal and only verified at 5% level, not at 1% level. They also cast doubt on the difference because of the small group size of the Afrikaans students taught in English, compared to the group taught in Afrikaans Gerber et al (2005:17 - 18).

Another study compared first language students receiving mathematics in their first language with second-language students receiving mathematics in English. The difference in performance between the two groups was found to be statistically insignificant Gerber et al (2005:10 - 18). The other investigation compared the performance of non-Afrikaans (predominantly African) second language students with that of Afrikaans first language students, with both group attending English lectures. The research showed that there was no difference in the performance of the two groups in mathematics conducted in English (Gerber et al 2005:10 - 18).

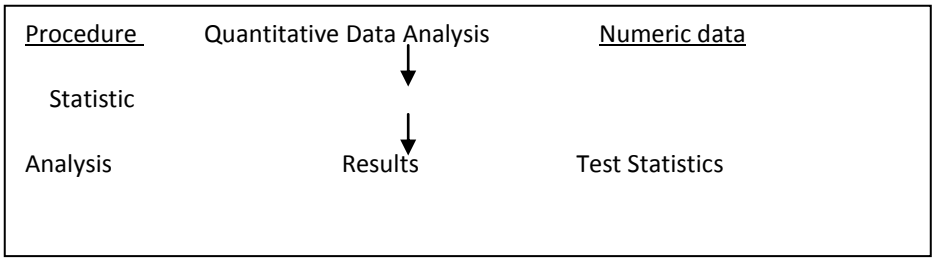
By drawing a distinction between non-Afrikaans second-language group and Afrikaans second-language group, Gerber et al (2005:10 - 18) studies seem to suggest that indigenous (non-Afrikaans) group was being considered as an entity that was being compared with other groups. Otherwise there would be no need to differentiate between first-language Afrikaans attending English lectures and second-language group also taught in English. Maybe one could find the differentiation justifiable, in the sense that the compatibility of the Afrikaans second-language group to English culture may dispose them differently to understanding English as compared to non-Afrikaans second-language group. One is reminded of the manner in which 'at least' is used by some Africans in their communication. An African man was once asked in a court of law how much bail he could afford. He said: "At least R300". It emerged in further discussion that by "At least R300" he actually meant 'At most R300'. The interpretation of 'at least' may differ for both the Afrikaans and non-Afrikaans speakers. In the South African context, the non-Afrikaans second-language group consists of people of different cultures. There are Amazulu, Batswana, Basotho, Bapedi, AmaXhosa etc.

This investigation looked at the non-Afrikaans second-language group as a heterogeneous group consisting of students with differing degrees of English proficiencies. The study focused on the impact of these proficiencies on first-year tertiary mathematics performance. First-year second-language students (of comparable grade 12 mathematical ability) with good grade 12 English marks (60 %+) were being compared (in terms of mathematics 1 performance) with students who got low grade 12 English marks (less than 49%).

4 . Research design

4.1. The approach needed to answer the quantitative research questions is depicted in the figure below:

Figure Research design



The following is a brief summary of the design:

The quantitative study involved maths 1 exam results for two groups of learners with a given grade 12 maths marks, with one group having scored lowly (below 49%) and the other highly (above 60%) in grade 12 English examination.

4.2. The approach needed to answer the research questions was a quantitative approach as depicted by the following table:

Table Design of the research

Research design	
Research question	Data collected to address the question
What is the impact of English proficiency on first-year mathematics performance by second language tertiary students at a University of Technology (UoT)?	Quantitative data: 2009 mathematics 1 examination marks of second language students with varying grade 12 English performances for a given grade 12 mathematics performance.

4.3. Research Methodology

4.3.1. Population and sample

The population consisted of all second-language students doing first-year mathematics for the first time at a UoT in South Africa. The sample design was deliberate or convenience sampling. The sample consisted of only those students who were doing first year directly from school. The group in each sample was formed according to how much the group member obtained in grade 12 mathematics. One group with the specified mathematics mark consisted of students who had obtained at least 60% in grade 12 English. This group was compared with another group with the same grade12 maths mark, but who had obtained at most 49% in grade12 English. For instance, the A-C group consisted of 30 students who obtained symbol A (80%+) in grade 12 maths and at least symbol C (60%+) in grade 12 English. The A-E group consisted of 14 students who obtained symbol A (80%+) in grade 12 maths and at most symbol E (49%-) in grade 12 English. The mathematics 1 marks of the two groups were compared, with a view of establishing if the grade 12 English mark had any impact on the maths1 mark. The following table summarises the groups.

TABLE Sample

Samples	Explanation
A-C (N=30) versus A-E (N=14)	Students who obtained symbol A (symbol 7 in NCS or 80%+) in grade 12 maths and at least symbol C (60%+) in grade 12 English were compared with those obtained symbol A in grade 12 maths and at most symbol E (NCS 49%-) in grade 12 English .
B-C (N=61) versus B-E(25)	Students who obtained B in grade 12 maths and at least symbol C (60%+) in grade 12 English were compared with those obtained symbol B in grade 12 maths and at most symbol E (NCS 49%-) in grade 12 English
C-C (N=62) Versus C-E(38)	Students who obtained C in grade 12 maths and at least symbol C (60%+) in grade 12 English were compared with those obtained symbol C in grade 12 maths and at most symbol E (NCS 49%-) in grade 12 English .
D-C (N=32) Versus D-E(14)	Students who obtained D in grade 12 maths and at least symbol C (60%+) in grade 12 English were compared with those obtained symbol D in grade 12 maths and at most symbol E (NCS 49%-) in grade 12 English

4.3.2. Measuring instruments: The 2009 mathematics 1 June examination mark was used as a measuring instrument for the performance of the two groups. What categorised the compared groups was the common symbol in grade 12 mathematics, with one group having score lowly (49%-) in grade 12 English while the other had scored highly (60%+). The mathematical categories were described in terms of symbols A, B, C and D. Their June examination marks were compared in an effort to establish the impact of grade 12 English marks on them.

4.3.3. Reliability and validity

The research design and methods in this study were focused on minimising the plausible alternative explanations for the cause-effect relationships by taking precautionary measures (Trochim, 2006):

To counter the possibility of some of the study candidates having come from better resourced schools, only students who obtained the same mathematics grade in grade 12 were compared. The first group to be compared consisted of 44 of those who had obtained symbol A in grade 12 mathematics, with 30 of them having got at least 60% in grade 12 English, while 14 had obtained 49% or less. The other compared groups are indicated in the table above.

The UoT students in the investigation were taught by 11 different lecturers. The impact of this on student performance was limited by the fact that students usually consulted any lecturer who is free at the time of their needing help in mathematics. In addition, there were mathematically competent tutors who were appointed to help students with their problems. They taught across the different class groups. To a limited extent, some students used their free periods to attend other mathematics classes covering the same topic, taught by a different lecturer, in order to maximise prospects of understanding. Also, students across different class groups formed mathematics discussion groups. These limited the impact of the student exposure to a particular lecturer's approach

All 276 students in the samples of the students at UoT were being assisted financially by the national body NAFSAS, other companies through bursaries, or could afford the fees. This limited the impact of socio-economic background of the students on their performance.

197 of the students were residence students, with 79 renting private rooms near the UoT. This limited parental encouragement and assistance as a factor that can impact on their mathematics performance.
UoT mathematics 1 repeaters or those who did bridging course (foundation mathematics) prior to doing mathematics 1 in 2009 courses were excluded from the study in order to minimise the impact of second chance on their mathematics 1 performance.
4.3.4. Data collection procedures.
Permission was requested and granted by the UoT examination office for release of the examination data for this study. The grade 12 results of the candidates qualifying in this study were also provided by UoT admission office.
4.3.5. Data analysis.
Quantitative analyses involving descriptive, as well as inferential statistical analysis were used. T-tests were used to establish significance of differences between the participating groups' performance. A statistical significance test was used to analyse the data.
5. Results
5.1. Introduction

The 2009 first-year UoT students consisted of learners who had followed the New Curriculum Statement (NCS). For convenience purpose, the NCS grading of results was converted to the 'old sylabus' equivalent. It is easier to deal with 'symbol A' than 'symbol 7'.

Table Equivalence of Old versus NCS symbols of results

Grade 12 symbols		
Old syllabus	NCS	Mark interval
A	7	80%+
B	6	70%-79%
C	5	60%-69%
D	4	50%-59%
E	3	40%-49%
F	2	0-39%

Most of the admitted first-year UoT students needed to have the equivalent of at least symbol E in their grade 12 marks. That is why in our data there are no categories that deal with symbol F.

5.2. Results
Tables 1 to 7 summarise the results. The sample A-C, for instance, consisted of marks of learners who had obtained symbol A in Grade 12 mathematics and symbols C and above in grade 12 English. Similarly, the sample A-D consisted of marks of learners who obtained symbol A in Grade 12 mathematics and symbol D in grade 12 English. All other samples were named similarly, with the first letter indicating the symbol obtained in grade 12 mathematics and the other letter(s) indicating the symbols obtained in grade 12 English. The following were the results.

Table 1 t-Test:

	A-C	A-E

Mean	54.33333	46.35714
Variance	475.5402	159.6319
Observations	30	14
Hypothesized Mean Difference	0	
df	40	
t Stat	1.52786	
P(T<=t) one-tail	0.067209	
t Critical one-tail	1.683851	
P(T<=t) two-tail	0.134417	
t Critical two-tail	2.021075	

The mean of maths 1 test for the students who had obtained symbol A in grade 12 maths and at least 60% in grade 12 English was 54,33%, while that of students who had obtained symbol A in grade 12 maths and at most 49% in grade 12 English was 46,36%. However, the difference in the means was statistically insignificant (p>0.05).

Table 2 t-Test:

	B-C	B-E
Mean	46.03279	45.36
Variance	328.5322	280.5733333
Observations	61	25
Hypothesized Mean Difference	0	
df	48	
t Stat	0.165086	
P(T<=t) one-tail	0.434785	
t Critical one-tail	1.677224	
P(T<=t) two-tail	0.86957	
t Critical two-tail	2.010635	

The mean of maths 1 test for the students who had obtained symbol B in grade 12 maths and at least 60% in grade 12 English was 46,03%, while that of students who had obtained symbol B in grade 12 maths and at most 49% in grade 12 English was 45,36%. However, the difference in the means was statistically insignificant (p=0,86957>0.05)

Table 3 t-Test:

	C-C	C-E
Mean	42.51613	44.86842105
Variance	305.5981	303.0362731
Observations	62	38
Hypothesized Mean Difference	0	
df	79	
t Stat	-0.65484	
P(T<=t) one-tail	0.257237	
t Critical one-tail	1.664371	
P(T<=t) two-tail	0.514473	
t Critical two-tail	1.99045	

The mean of maths 1 test for the students who had obtained symbol C in grade 12 maths and at least 60% in grade 12 English was 42,52%, while that of students who had obtained symbol C in grade 12 maths and at most 49% in grade 12

English was 44,87%. However, the difference in the means was statistically insignificant (p=0,514473>0.05).

Table 4. t-Test:

	D-C	D-E
Mean	42.875	37.14285714
Variance	188.6935	360.4395604
Observations	32	14
Hypothesized Mean Difference	0	
df	19	
t Stat	1.01902	
P(T<=t) one-tail	0.160497	
t Critical one-tail	1.729133	
P(T<=t) two-tail	0.320995	
t Critical two-tail	2.093024	

The mean of maths 1 test for the students who had obtained symbol D in grade 12 maths and at least 60% in grade 12 English was 42,875%, while that of students who had obtained symbol D in grade 12 maths and at most 49% in grade 12 English was 37,14285714%. However, the difference in the means was statistically insignificant (p=0,320995>0.05).

The following was a summary of the Maths 1 test results.
Specifically, the following p-values were obtained for each comparison:

Table number	Groups compared	p-value	Conclusion
1	A-C versus A-E	0.134417	Difference in means not statistically significant
2	B-C versus B-E	0.86957	Difference in means not statistically significant
3	C-C versus C-E	0.514473	Difference in means not statistically significant
4	D-C versus D-E	0.320995	Difference in means not statistically significant

In all of the compared groups, the difference between the mathematics 1 examination performance was not statistically significant (p>0.05).

6. Conclusions and recommendations

The fact that the difference between the means of the groups that were compared, with one group having scored better English marks in grade 12 than the other, was statistically insignificant, implies that proficiency in English as defined in terms of grade 12 marks did not necessarily lead to better performance in mathematics 1 performance. That means that some tertiary institution's use of English marks as a criterion for the language intervention is not backed by the research results in this paper. Maybe what this meant was that grade 12 English is not sufficient to enable the student to cope with the language demands of tertiary courses. This could mean the students need more practice on English communication, which could justify other South African tertiary

institutions' compelling all first-year students to do the compulsory English communication course. But then the impact of this intervention also needs to be researched. The other possibility is that lack of statistical significance in the performance of the groups being compared could be attributed to the fact that mathematics is not too language - intensive, making it possible for a student who is proficient in English to perform similar to the one who is not proficient. This could possibly explain lack of transfer of mathematics to field of its application like engineering. This leaves a room for checking how students perform in word problems as compared symbolic problems covering the same mathematical principles. This will inform the practitioners how the students are hampered by use of language in mathematics. Finally, the other reason for there being no statistical significance between the performance results of the groups could be because proficiency in generic English would not make as much difference as when the intervention English was specifically targeted for mathematics students. In other words, maybe the targeted English intervention, one for the Humanities students and the other one for the Sciences, could impact more profoundly on mathematics 1 performance. More research needs to be done on this topic.

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