A BASIC MATHEMATICAL SKILLS TEST AS A PREDICTOR OF PERFORMANCE IN MATHEMATICS AT TERTIARY LEVEL

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The extent to which performance in mathematics and English in the final school year as well as an independent test for the measurement of basic mathematical skills serve as predictors of success during the first semester of study at tertiary level was explored. Students, admitted to a bridging programme in science, engineering and technology at a large tertiary institution in South Africa during 2005, formed the target population. The link between having received home language tuition during three stages of schooling and being successful was also explored. It was shown that the basic mathematical skills test, measuring three theoretical dimensions, namely mathematics language proficiency, problem solving skills as well as computational skills in combination with performance in mathematics at school level significantly contribute towards the prediction of success. No support was found that having received home language tuition contributes towards success.

CONTEXT

Increasing the number of science-based graduates to meet the technological challenges of the 21st century is imperative for economic sustainability and growth of South Africa (SA) (Cape Argus, 2005). This is highlighted by the demand in the labour force for graduates in science, engineering and technology (SET) and the fact that it is a key objective of the South African National Plan for Higher Education (NPHE) to shift the balance of enrolment to tertiary studies from the humanities to business and commerce and particularly SET (Department of Education, 2001: 25-26). In fact, increasing the scientific base of SA has become a burning issue in education (Maree, Malan & Basson, 2002). Universities in SA have risen to the challenge of the NPHE by instituting extended degree or bridging programmes to students who satisfy less stringent admission criteria than those set for students admitted to degree programmes.

THEORETICAL FRAMEWORK

Due to its widely accepted predictive validity, passing mathematics in the final school year is an admission requirement for undergraduate studies in SET, irrespective of whether it is for a degree or bridging program. As such, mathematics has been described as the gateway to careers in SET (Furner & Bernan., 2003). However, admission requirements based on achievement in the final school year alone have been, and continue to be contentious in SA due to historical differences in the education systems at school level during the apartheid era (Department of Education, 2003: 62; Skuy, Zolezzi, Mentis, Fridjohn & Cockcroft, 1996; Zaaiman, Van Der Flier & Thijs, 2000). Despite changes in the education system at school, these differences have not been eradicated yet. In addition, many students, most notably those from historically disadvantaged communities, are believed to enter universities under-prepared for the challenges associated with tertiary education despite satisfying the admission criteria (Nolan, 2002; Skuy et al., 1996). In SA the problem of under-preparedness is exacerbated by the fact that for the vast majority of learners at school and

students at university, learning takes place in the second (even third or fourth) language, i.e. English. In addition, due to the fact that SA has eleven official languages, English second language (ESL) students in SA are not a homogeneous group as they come from a variety of cultural and socio-economic backgrounds (Naudé, Engelbrecht, Harding & Rogan, 2005.)

The fact that there is doubt, both locally and internationally as to the extent to which Grade 12 mathematics results reflect the extent to which students have acquired basic mathematical skills, has resulted in the development of alternative measures being adopted by universities to independently measure basic mathematical skills and competencies of students. What is considered in the literature to constitute basic mathematical skills also differs and depends on the purpose for which the instrument is intended. In general, basic mathematical skills tests focus on the measurement of numeric and computational skills (calculations), algebraic skills, basic problem solving skills and knowledge of mathematical words and terminology (mathematics vocabulary and comprehension) (Armstrong & Croft, 1999; Nolan, 2002; Zaaiman et al., 2000) as well as calculus skills (Armstrong et al., 1999).

Apart from the obvious advantages of an independent measure for the measurement of basic mathematical skills, namely of placing students in an appropriate mathematics course at university or providing assistance to students at the onset of their studies, one of the most important advantages is the fact that it can be used to assess the extent to which basic mathematical skills of students change over the years (Lawson, 2003): it thus facilitates the creation of a basis of comparison. This aspect is of particular importance to universities in SA due to the fact that, at school level, an outcomes based education system (OBE) has been introduced and the mathematics curriculum has changed. The first students schooled under the OBE system are expected to enter universities by 2009.

PURPOSE

It is within this theoretical framework that a quantitative exploratory study was undertaken at the University of Johannesburg (UJ) during 2005 to ascertain the extent to which background characteristics and cognitive factors associated with school learning, i.e. basic mathematical skills and competencies, serve as predictors of performance in mathematics during the first semester at university of students admitted to a bridging programme in SET. The main purpose of the study was the identification of students who are under-prepared for tertiary studies in SET with the aim of implementing appropriate support structures to assist these students.

INSTRUMENTS

Due to the reported importance of home language tuition in mathematics during early years at school (Maree & Beck, 2004; Sibaya, Sibaya & Mugisha, 1996), background characteristics considered in this study referred specifically to the congruence between the student's home language and the language of learning in mathematics during three stages of schooling.

Cognitive factors associated with school learning were operationalised in two ways: the students' performance in both mathematics and English during their final year at school and the students' performance in an independent cognitive test (the Basix²) of the extent to which students have acquired basic mathematical skills. The Basix² questionnaire was developed for the purposes of this

study as a cognitive diagnostic tool for the measurement of the extent to which students admitted to the bridging programme in SET have acquired basic mathematical skills prior to entering the institution.

The underlying constructs of the Basix² questionnaire were informed by the literature and particularly by the reported relationship between language proficiency and performance in mathematics (Naudé et al., 2005; Sibaya et al., 1996). Items of the questionnaire covered three dimensions, i.e. knowledge of mathematical vocabulary and terminology or mathematics language proficiency, problem solving ability as well as computational skills. The questionnaire consists of a total of 25 items. A multiple-choice response format is used, i.e. for each item (question) five alternative answers are provided of which only one is correct while the other four alternatives are plausible but incorrect answers.

METHODOLOGY

Students admitted to a bridging programme in SET in 2005 formed the target population, i.e. the study was a localised cross-sectional study. Due to ethical considerations, participation was voluntary and only those students providing written consent participated in the study. Participating students completed the background and Basix² questionnaires during a formal class at the beginning of the 2005 academic year. Due to the fact that the criterion variable in this study was first semester performance in mathematics, the final sample consisted of those students who took part in the survey and who obtained a first semester mark in mathematics, i.e. students who did not drop out of the mathematics course during the first semester.

RESULTS

Of the 377 students in the bridging programme who obtained first semester mark in mathematics, 216 participated in the survey, i.e. the response rate was 57.3%. The majority of the students was male (60%) and 124 (57.4%) were 18 years or younger. In terms of home language, more than 50% indicated speaking an African language, i.e. coming from a historically disadvantaged community in SA. The percentage of student not being taught mathematics in their home language increased from approximately 40% in Grade 1 to 3, to approximately 52% in Grades 8 to 12.

Performance in the basic mathematical skills test (referred to as the Basix² percentage) ranged from a minimum of 0 to 86% with an average of 51.3% (SD=18.03). In terms of the criterion, i.e. performance during the first semester, the average first semester score in mathematics was 46.3% (SD=19.62). Of the 216 students in the study, 119 (approximately 55%) were successful in the first semester, i.e. obtained a first semester score of 50% or higher.

The correlations between the Basix² percentage and performance in English in the final school year was significant (r=0.237; p-value<0.005) while the correlation between the Basix² percentage and performance in mathematics in the final year at school was not significant (p-value = 0.111). The correlation between the Basix² percentage and performance during the first semester was significant (r = 0.215; p-value < 0.0005).

In terms of group differences, students who received home language tuition during the three periods of schooling obtained significantly higher scores on average in both English in the final year at school as well as the Basix² questionnaire than those who did not receive home language tuition (p-

value < 0.0005 in each case). No significant differences were, however, observed between these groups in terms of their performance in mathematics at school level or during the first semester at university (p-values>0.05 in each case).

Step-wise logistic regression with performance in the Basix² questionnaire, performance in the final year at school in both English and mathematics and the congruence between home language and language of tuition during the three stages of schooling as predictor variables was used to determine the extent to which these can contribute towards the prediction of whether a student is successful / not successful during the first semester.

Two of the predictor variables entered the model, i.e. the Basix² percentage and performance in mathematics at school. Overall the model predicted 61% of the student in the correct group (i.e. either successful or unsuccessful), i.e. 46% of unsuccessful students and 73% of successful students. The Basix² percentage alone predicted 60% of the students in the correct group, i.e. 40% of unsuccessful and 78% of successful students. The addition of performance in mathematics in the final school year thus marginally improves the predictive ability of the model.

CONCLUSIONS

The study provides support for the use of an independent test for the measurement of basic mathematical skills of students admitted to a bridging programme in SET as a diagnostic tool for identifying students who are under-prepared for tertiary studies. The relationship between performance in English at school level and performance in the basic mathematical skills test as well as the fact that performance in the basic mathematical skills test is a significant predictor of success in the first semester lends support to the argument that English language proficiency, including mathematics language proficiency or academic language proficiency plays a role in terms of performance in mathematics at tertiary level.

Recommendations emanating from this study pertain to universities in SA, lecturers and those embarking on future research relating to the theme in question and include recommendations regarding the issue of measuring basic mathematical skills, including mathematical language proficiency of students studying towards careers in SET at the onset of their studies and providing support to improve these.

Endnotes

1 This study formed part of a larger study on the prediction of performance in the first semester of students admitted to both a degree and bridging programme in SET. The study not only spanned the cognitive, but also the affective and behavioural domains (not reported on in this paper).

2 The full article on which this abstract is based has been accepted for publication in the South African Journal of Higher Education (http://www.sajhe.org.za/).

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