IS MATHEMATICS STILL RELEVANT AS AN ADMISSION CRITERION FOR ENTRY INTO AN INFORMATION AND COMMUNICATION TECHNOLOGY COURSE AT A SOUTH AFRICAN UNIVERSITY?

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Abstract

It is well documented in the literature that computer programming modules in higher education institutions are characterised by low success rates. Several reasons could be attributed to this situation, from the difficulty of the subject itself to the lack of problem solving abilities of the students. This paper reports on a study conducted at a South African university to determine the extent to which students' Grade 12 mathematics results can predict the success of first-year students enrolled for a programming module in an ICT course.

Introduction

It is well documented in literature (see for example Garner, 2007; Butler & Morgan, 2007; Robins, Rountree, & Rountree, 2003; Corney, Teague, & Thomas, 2010; Ali & Shubra, 2010) that computer-programming modules at Higher Education Institutions (HEIs) are characterised by low success rates. Teaching novice programmers to programme is and always will be a challenge, and it has been stated that failure rates for first level programming courses can be as high as fifty percent (Caspersen, 2007).

The factors that influence students' success or failure in computer programming have been researched for several decades now (Wileman, Konvalina, & Stephens, 1981; Goold & Rimmer, 2000; Wilson & Shrock, 2001). It became apparent that a lack of problem-solving skills and poorly developed mathematical knowledge and skills of students who enrolled for programming courses, was a significant contributing factor in predicting success or failure in these courses. Mathematics focuses on an abstract, deductive discipline that is required in the scientific, technological and engineering world (Venkat, 2007). Bohlmann and Pretorius (2008, p. 43) claimed that "the conceptual complexity and problem-solving nature of Mathematics make extensive demands on the reasoning, interpretive and strategic skills of learners," which are needed for computer programming.

According to Feza-Piyose (2012) the majority of South African students demonstrate a poor performance in mathematics. She attributes this to the poor quality of teaching in schools as well as the lack of content knowledge of the teachers. The Centre for Development and Enterprise (CDE) recently reported that not enough teachers are being produced in South Africa, especially in the important subjects of mathematics and science. The Department of Basic Education (DBE) confirmed that South Africa had a shortage of 4,890 mathematics teachers and 4,551 science teachers nationally in 2008 (Jacobs, 2013). The teaching system is producing about a third of South Africa's requirement of about 25 000 new teachers a year ("SA needs 15,000 more teachers a year," 2011), and only a few students graduate in mathematics and science.

The challenge for the Department of Basic Education emanates from teachers' low salaries and poor working conditions which are identified as strategic areas in need of improvement in order to recruit new and retain experienced teachers in the profession (Nilsson, 2003). Currently the Department of Basic Education has a bursary scheme in place, offering a four year bursary to students studying a Bachelor's Degree in Education, specifically targeting mathematics and other scarce skills educators in order to attract students (Jacobs, 2013).

In a report published in October 2013 and commissioned by the Centre for Development and Enterprise, it is stated that South Africa "has the worst education system of all middle-income countries" and learners "perform worse than in many low-income African countries" (Spaull, 2013, p. 3). The quality of South African education is demonstrated by statistics indicating that out of 100 learners, who start school, 50 will reach Grade 12, 40 will pass, and only 12 will qualify to study at a university (Spaull, 2013).

The summarised results of the National Senior Certificate (NSC) examinations for mathematics (from 2011 to 2014) are shown in Table 1, which clearly supports the report's findings.

Table 1

Overall Achievement in Mathematics, Diagnostic Report: National Senior Certificate Examination 2014.

Year	0 to 39.9%	40 to 100%
2011	69.80%	30.20%
2012	64.30%	35.60%
2013	59.50%	40.40%
2014	65%	35%
Average over 4 years	64.65%	35.30%

Note: Adapted from *National Senior Certificate Examination 2014, Diagnostic Report*. Department of Basic Education, (Pretoria, South Africa, p 110).

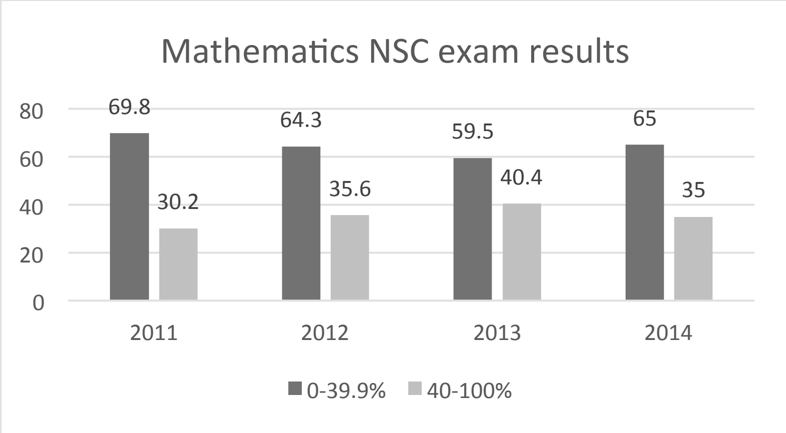

Figure 1. Overall achievement in mathematics for the years 2011-2014**.** Note: From *National Senior Certificate Examination 2014, Diagnostic Report*. Department of Basic Education, (South Africa, p 110).

Studies have shown a positive relationship between performance in mathematics and success in computer programming courses (Byrne & Lyons, 2001; Wilson & Shrock, 2001; Gomes & Mendes, 2008; Bergin & Reilly, 2005). However, Figure 1 confirms that in the last four years, in South Africa where this study was conducted, 65% of students are achieving between 0% and 39.9% for mathematics in their Grade 12 year. When Hourigan and O'Donoghue (2007) studied students enrolled for programming courses at HEIs, they identified the following areas of concern regarding their mathematical skills:

- Lack of mathematical knowledge
- Underdeveloped numeracy skills that are necessary to do basic calculations needed in their daily lives
- Low competency levels in Algebra
- An inability to apply mathematics in new contexts, different from the ones they encountered in previous exercises
- Inadequate mathematical reasoning abilities, i.e., problem solving skills

Selection criteria for an Information Technology (IT) diploma or degree is dependent on the results of the National Senior Certificate Examination (NSC), and particularly for mathematics. There is a common belief that a student who does well in high school mathematics will also do well in Computer Science (Goold & Rimmer, 2000; Spark, 2005). South African HEIs are however, questioning the validity of Grade 12 marks particularly for students who come from disadvantaged schools (Jenkings, 2004; Marnewick, 2012).

The Study

In order to determine whether the results of students who wrote the NSC mathematics is a good indicator of their academic performance in a programming module, their NSC mathematics results were compared to their final results in the first year programming modules. The sample for the study was a group of 82 randomly selected first year students at the Tshwane University of Technology (TUT), Pretoria, South Africa who were enrolled for the National Diploma: Information Technology (Course Code NDIT12).

In order to qualify for entry to the ND: IT, students must have achieved the NSC with the following scores: Mathematics level 4 (50% – 59%), English level 3 (40% - 49%) and an Admission Point Score (APS) of 18 (or more) at TUT. A student's APS into universities in South Africa is calculated as shown in Table 2

Table 2

National Senior Certificate Achievement Levels

%	100-80	79-70	69-60	59-50	49-40	39-30	29-20	19-10	9-0
NSC Level	7	6	5	4	3	2	1	1	1
Symbol	A	B	C	D	E	F	G	H	I

Note: Adapted from Schoer, Ntuli, Rankin, Sebastiao, & Hunt (2010). A blurred signal? The usefulness of National Senior Certificate (NSC) mathematics marks as predictors of academic performance at university level. *Perspectives in Education, 28*(2), 9-18.

The programming modules in the first year at TUT, *Development Software 1A* (DSO171AT) and *Development Software 1B* (DSO171BT) cover basic programming principles that are practically applied in VB.NET and expand the students' knowledge on programming principles and VB.NET. These two modules are prerequisites for all second year programming modules. The students' Grade 12 mathematics results were compared with their performance in the two programming modules using correlational statistical techniques.

Findings

A Pearson product-moment correlation coefficient was computed to assess the relationship between the students' performance in mathematics in Grade 12 and performance in Development Software 1 A.

Table 3

Correlation Between Students Grade 12 Mathematics Results and Performance in Development Software 1 A

		Development Software 1A	Grade 12 Mathematics
Development Software 1A	Pearson Correlation	1	.345**
	Sig. (2-tailed)		.002
	N	82	82
Grade 12 Mathematics	Pearson Correlation	.345**	1
	Sig. (2-tailed)	.002	
	N	82	82
**. Correlation is significant at the 0.01 level (2-tailed)			

As shown in Table 3, there was a weak positive correlation between the two variables, r = .345, n = 82, p = .002. It can therefore be concluded that there is a weak correlation between a student's NSC result for mathematics and final mark obtained for Development Software 1 A.

A Pearson product-moment correlation coefficient was computed to assess the relationship between the students' performance in mathematics in Grade 12 and performance in Development Software 1 B.

Table 4

Correlation between Students Grade 12 Mathematics Results and Performance in Development Software 1 B

		Grade 12 Mathematics	Development Software 1B
Grade 12 Mathematics	Pearson Correlation	1	.261*
	Sig. (2-tailed)		.018
	N	82	82
Development Software 1B	Pearson Correlation	.261*	1
	Sig. (2-tailed)	.018	
	N	82	82
*. Correlation is significant at the 0.05 level (2-tailed)			

As shown in Table 4, there was a weak positive correlation between the two variables, r = .261, n = 82, p = .018. It can be concluded that there is a weak correlation between a student's NSC result for mathematics and final mark obtained for Development Software 1 B.

Conclusion

The findings indicate that in this study a South African student's NSC mathematics marks had a weak correlation with performance in the programming courses at the first year university level. This is consistent with the findings of Byrne and Lyons, (2001), Wilson and Shrock (2001), Gomes and Mendes (2008), and Bergin and Reilly (2005) who claim that performance in mathematics can predict programming performance. The TUT in conjunction with the University of Johannesburg are currently doing further research in identifying predictors for success in computer programming modules in order to gain insight into the programming needs of the students. The envisaged research findings, their implications and the conclusions will provide an opportunity to identify a better selection process for programming students and develop supporting learning activities that will assist students in becoming successful in their programming module.

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