High school mathematics marks as an admission criterion for entry into programming courses at a South African university

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ABSTRACT

In this study, the assumption that good performance in mathematics in the final school year could be used as a pre-entry requirement to programming courses at universities in South Africa, is challenged. The extant literature reports positive relationships between mathematics performance and success in programming courses. As computer programming modules in higher education institutions (HEIs) are typically characterised by low success rates, it becomes important to eliminate potentially erroneous entry requirements. The low success rate in programming modules is ascribed to the abstract nature and content of programming courses, and the inadequacy of pre-university education to prepare students for the cognitive skills required for success in such programmes. This paper reports on a single independent variable, 'performance in high school mathematics', and its relationship to performance in two computer programming courses. The dataset comprised the school marks of four cohorts of students who were enrolled for the programming modules between 2012 and 2015. Firstly, we computed the point-biserial correlation between a dichotomous variable that indicated whether students had mathematics as a subject in Grade 12 or not, and their performance in the programming modules. Once we established that a relationship existed, the marks achieved in the final school year for mathematics, and performance in two programming modules were correlated. Results indicated that the school mathematics marks correlate only marginally, and that correlations were not significant, with performance in the two programming courses. We also correlated the school mathematical literacy marks with performance in the two programming courses, and found that a strong positive correlation that was significant existed with the second semester programming course. We conclude that the mark achieved for school mathematics cannot be considered as a valid admission criterion for programming courses in the South African context.

Keywords: mathematics, higher education, enrolment criteria, computer programming

INTRODUCTION

This paper reports on the relationship that exists between a single variable, 'performance in school mathematics', and performance in two first-year level programming courses at a university in Johannesburg, South Africa. The exploration of the variable forms part of a larger project that attempts to isolate variables that influence the readiness of school leavers in South Africa to enrol for, and be successful in, programming courses. As part of our investigations, we have extensively explored a number of pre-entry variables that could influence the proclivity of school leavers to be successful in the university courses. These include: living conditions, living standard means, schooling variables like teacher pedagogical stances, access to learning materials, access and use of ICT, the development of critical thinking skills, (also at home), cultural views on authority, and the achievement of learners in their final year school examinations.[2] In this paper, we report on a single variable, which is the final scores achieved by students in mathematics at the school level, and how these scores relate to their performance in the programming modules. As will become evident subsequently, our findings contradict knowledge in this regard. The extant literature reports positive relationships between mathematics performance and success in programming courses. Our findings also contradict what common sense expected us to find. How could this be? We acknowledge that the examination of a single independent variable is insufficient to explain the success (or lack of success) of the students who enrol for these modules. Yet, the magnitude of the evidence that our results contradict, places the very validity of the variable that we examined in question. The implication of that is virtually unthinkable: Can the performance of learners in their subjects be an inaccurate reflection of their abilities, and can these performances therefore not be scientifically related to their capacity to be successful in higher education courses?

NATIONAL CONTEX

In South Africa, learners in their last three years of schooling (Grade 10 – 12) have to take seven subjects. Four of these subjects are mandatory: English (either as first or second language), a second approved language (again, either as first or second language), Life Orientation, and either Mathematics or Mathematical Literacy. Additionally, learners must select three other subjects from a host of disciplines. These include subjects like Geography, Physical Sciences, Life Sciences, Agricultural Sciences, History, Accounting, Business Studies, Economics, etc. (Department of Basic Education, 2015).

At the end of the academic year, Grade 12 learners write national examinations in all their subjects. These national examination papers are set by the Department of Basic Education (DBE). The examination scripts (or other assessment artefacts like art work) are marked and moderated by independent panels of markers, who are teachers who need to apply and meet certain criteria, before being appointed as a marker. The final marks that are achieved for each subject is expressed as a percentage. The final marks for each subject constitute a combination of marks earned during the school year, and the marks achieved during the national examinations. The marks of six subjects (Life Orientation is excluded) are used to calculate an 'Admission Point Score' (APS), as is seen in Table 1 (IEB, 2015).

Table 1:
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

Source: Adapted from Schoer et al. (2010)

2 In a separate, concurrent project, we are considering the results of our investigations, as we attempt to derive design principles, using design-based research methodologies, to re-design the pedagogical approaches by which these two first-year level programming courses are taught.

Previously, universities used the APS score to determine whether, and to which programmes, prospective students may be admitted. Minimum APS scores are required for admittance to particular programmes, and may differ between institutions. Programmes that are considered to be difficult to be successful in may require higher APS scores than programmes that are considered easier. For example, admission to humanities programmes may require an APS score of 30, whereas admission to engineering programmes may require a higher APS score of 35 (University of Pretoria, 2015a, 2015b respectively). In addition, a sub-minimum mark in specific school subjects may be required before admission to certain programmes is considered.

Lately however, universities do not consider the APS score as an accurate measure for admission to their higher education programmes (Hunt, Rankin, Schoer, Nthuli & Sebastiao, 2009) for a number of reasons. The validity of Grade 12 final examination results are being questioned nationally by the public, educational experts and by universities. The marks of students who come from 'disadvantaged' schools are particularly questioned for a number of reasons (Jenkings, 2004; Marnewick, 2012). Firstly, it is believed that matriculation results are politically manipulated to show an improved performance of the school education system overall, and especially so since democratisation in 1994. Secondly, the marks achieved by learners undergo a process of standardisation by Umalusi, the Council for Quality Assurance in General and Further Education and Training after a process of a review of the marks in order 'to mitigate fluctuations in learner performance that are a result of factors within the examination process itself'. Therefore, marks may be adjusted upwards or downwards by as much as 10% in any subject that was written during the national examination to align with historical performance trends in the particular subject (Parliament.gov.za, 2014). Thirdly, reports in the local press indicate rife large-scale cheating during the examinations by learners. Approximately 5300 learners were investigated for irregularities during the 2014 National Senior Certificate (NSC) examinations (SAnews, 2015). Umalusi's moderation processes identified 'group copying' in maths, economics and business studies. It was also found that there had been 'evidence of possible assistance by an invigilator or exams official' in the mathematics paper, which was written by 174 candidates (Times Live, 2015). Finally, according to the South African Democratic Teachers Union (SADTU), 'Schools are manipulating the learner promotion and progress because of pressure to produce better Senior Certificate results' (2015). It has been reported that schools manipulate marks, or alternatively, that the progression of learners through the grades are artificially managed by holding learners back in some grades and advancing them through others.

Annually, the examination results are published in local newspapers, and learners may on the same day collect their official results and certificates from their former schools. Typically, a news conference is called by the ministry, and the official 'matric pass rate' is made known. The official pass rate that has steadily been rising over the past number of years, warrants further scrutiny, warns Van der Westhuizen (2013). He points out that the 'Class of 2012' had a published pass rate of 73.9%. However, this number disregards the 620 000 learners who have dropped out of the educational system since 2001, the year that this cohort of students entered formal schooling. Therefore, the success rate of the cohort is a more sobering 37%. This alternative perspective on the pass rate raises further questions on the quality of South African school education.

Certainly, the performance of South African school learners in international benchmark tests supports the concerns raised above. South African learners participated in three international benchmarking studies during the past decade: Trends in Mathematics and Science Studies 2011 (TIMSS), Progress in International Reading Literacy (PIRLS) and Southern and Eastern Africa Consortium for Monitoring Education Quality (SACMEQ). The results show that South African learners consistently perform poorly in comparison to its more impoverished neighbours, and very poorly in comparison to developing countries in other parts of the world (Taylor, Fleisch & Schindler, 2008). The Global Information Technology Report of 2013 ranks South Africa 143 out of 144 countries for mathematics and science education and 140 out of 145 for overall quality of their education system. This is worse than many of the world's poorest nations in mathematics and science; only Yemen ranks lower (World Economic Forum, 2013).

University dropout rates in South Africa is alarming. By the end of the first year, 30% of students will have dropped out. A year later, a further 20% will drop out. Van Zyl reports that 41% of students who enter higher education will eventually drop out (News24, 2015). University academics report that first-year students are simply not ready for the demands of higher education.

Against this background, 'The National Benchmark Tests (NBTs) were commissioned by Higher Education South Africa (HESA) with the task of assessing the academic readiness of first-year university students as a supplement to secondary school reports on learning achieved in content specific courses' (NBT, 2011). The NBTs assess competency in Academic Literacy (AL), Quantitative Literacy (QL) and Mathematics (MAT), all which may directly impact first-year university students' likelihood of success (Marnewick, 2012). The results of the NBTs inform universities about the level of academic support that students may need to be successful in their chosen field of study. The results are also used by universities for programme planning. Most universities now require prospective students to write the NBT examinations, and will admit students to their programmes based on the scores obtained in those examinations.

Since 2008, educational policy in South Africa dictates that for the last three years of schooling, learners have to select either mathematics or mathematical literacy as one of the seven compulsory subjects. Prior to this, mathematics was not a compulsory subject, and those learners who chose it could do so either at a 'higher grade' or 'standard grade' level (Pasensie, 2012). Only 60% of students opted to take mathematics for the final three years of schooling between the years 2000 and 2005. Of those, the vast majority opted for the standard grade level, and only 5.2% of all learners in the country passed mathematics at the higher grade level (Clark, 2012). The new curriculum that was introduced in 2008 abandoned the level options of higher grade or standard grade for each subject. A new subject, mathematical literacy, was introduced, and learners must choose between mathematics and mathematical literacy for Grades 10–12 (Spangenberg, 2012). Mathematical literacy equips and sensitises learners with an understanding of the relevance of mathematics in real-life situations (Department of Basic Education, 2011a). Typical topics in mathematical literacy include learning how to calculate income tax, how to calculate the cost of buying a house, including calculating transfer fees, legal fees and bond repayment amounts (Clark, 2012). Mathematical literacy creates a consciousness about the role of mathematics in the modern world and is therefore driven by practical applications. The subject develops the ability and confidence of learners to think numerically in order to interpret daily situations (Department of Basic Education, 2011a). Mathematical literacy was specifically introduced as an intervention to improve the numeracy skills of South African citizens, in response to poor performance in mathematics in the past (Pasensie, 2012). For many learners, especially learners from rural areas, mathematical literacy may be their only opportunity of acquiring any mathematical skills at all. Some of the differences between these two subjects are tabulated in Table 2.

Table 2:
Focus differences between Mathematics and Mathematical Literacy as prescribed by the National Curriculum Statement

Example content from the Mathematics curriculum	Example content from the Mathematical Literacy curriculum
Number and number relationships: • Convert between terminating or recurring decimals • Fluctuation foreign exchange rate	**Number and operations in context:** • Percentage • Ratio • Direct and inverse proportion • Scientific notation

Example content from the Mathematics curriculum	Example content from the Mathematical Literacy curriculum
Functions and algebra: • Graphs to make and test conjectures and to generalise the effects of the parameters a and q on the graphs • Algebraic fractions with monomial denominators • Linear inequalities in one variable • Linear equations in two variables simultaneously	**Functional relationships:** • Numerical data and formula in a variety of real-life situations, in order to establish relationships between variables by finding the dependent variable and the independent variable
Space, shape and measurement: • Volume and surface area of cylinders • Co-ordinate geometry • The trigonometric functions sinϑ, cosϑ and tanϑ, and solve problems in two dimensions by using the trigonometric functions in right-angle triangles	**Space, shape and measurement:** • International time zones • Circles • Draw and interpret scale drawings of plants to represent and identify views
Data handling and probability: • Measures of dispersion (range, percentiles, quartiles, interquartile and semi-interquartile range) • Frequency polygons • Venn diagrams	**Data handling:** • Investigate situations in own life by formulating questions on issues such as those related to social, environmental and political factors, people's opinions, human rights and inclusivity • Collect or find data by appropriate methods (e.g. interviews, questionnaires, the use of databases) suited to the purpose of drawing conclusions to the questions • Representative samples from populations

(Spangenberg, 2012)

Performance in mathematics has traditionally been considered a primary predictor of success in programming courses, and several studies showed that a positive relationship exists between performance in mathematics and success in computer programming courses (Byrne & Lyons, 2001; Wilson & Shrock, 2001; Gomes & Mendes, 2008; Bergin & Reilly, 2005). Mathematics as an academic subject which focuses on abstract, deductive reasoning and problem solving, is a discipline that is required in the scientific, technological and engineering world (Venkat, 2007) where the ability to 'think logically and systematically, reason, judge, calculate, compare, reflect and summarise' (Department of Basic Education, 2011b) is of paramount importance. Bohlmann & Pretorius (2008: 43) claim 'the conceptual complexity and problem-solving nature of Mathematics make extensive demands on the reasoning, interpretive and strategic skills of learners'. The skills that are associated with mathematics learning are considered essential for learning programming during computer programming courses. 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). Gomes & Mendes (2008) showed that the majority of the novice programming students in their study did not possess the necessary basic mathematical conceptual understanding that was expected, and that in turn affected their problem-solving ability, and resulted in poor programming skills development. Spark (2005) showed that the level (previously Higher Grade and Standard Grade) at which mathematics was taken, and not the marks that they achieved, more accurately reflected their ability to learn how to programme. Students who took mathematics on the standard grade did not perform as well in the programming courses as the students who took mathematics at the higher grade.

How did South African learners perform in mathematics and mathematical literacy after 2010, when the first matriculants of the new curriculum wrote the national examinations? Table 3 and Table 4 tabulate this data.

Table 3:
Learners' performance in Mathematical Literacy for 2011-2014

Year	Total Grade 12 Learner Enrolment	Wrote		
2011	511 038	275 380	178 899	65.0
2012	527 572	291 341	178 498	61.4
2013	575 508	324 097	202 291	62.4
2014	550 127	312 054	185 528	59.5

(Department of Basic Education, 2015)

Table 4:
Learners' performance in Mathematics for 2011-2014

Year	Total Grade 12 Learner Enrolment	Wrote		
2011	511 038	224 635	61 592	30.1
2012	527 572	225 874	80 716	35.7
2013	575 508	241 509	97 790	40.5
2014	550 127	225 458	79 050	35.1

(Department of Basic Education, 2015)

It is clear that a small proportion of the total learner enrolment in Grade 12 selected mathematics as a subject. This has severe implications for the training of programmers, as mathematical literacy is not considered appropriate for selection for programming courses at several universities.

Several questions arise from the aforementioned discussion. Whereas it would almost be impossible to establish causal relationships between performance in mathematics at the school level, and success in programming courses, in the context of the South African educational system it becomes important to establish whether any relationships exist at all between performance in school subjects and success in higher education courses. If no such relationships can be quantified and verified, it would mean that the use of school exit performances cannot be used as criteria to grant access to higher education, and that other mechanisms would have to be found to predict or anticipate success at the university level for the school leavers of the South African school education system.

The purpose of this paper therefore is to establish what correlational relationships exist between performance in school mathematics, and success in first-year level programming courses. This will enable us to establish the validity of using the school subject results as an admission criterion to programming courses.

THE COURSES

The National Diploma: Information Technology (NDIT) is offered by Universities of Technology (formerly known as 'Technikons') and comprehensive universities across South Africa. Admission to the programme is dependent on the performance of school leavers during the National Senior Certificate Examination

(NSC). The admission criteria for the diploma at the urban university in Johannesburg where this study was conducted, required a minimum mark of 40% for mathematics, or 70% for mathematical literacy. In addition, applicants had to pass English with a mark of higher than 50%. An APS score of 24 with mathematics or 26 with mathematical literacy is further required.

The programming modules in the first year are *Development Software 1A* (DSW01A1) presented in the first semester of the academic year (February – May) and *Development Software 1B* (DSW01B1) presented in the second semester (July – November). These courses cover the basic programming principles that are practically applied in Java. The modules provide an introduction to a programming environment, assuming that the student does not have any previous knowledge or experience of any programming languages. The course is meant for beginner programmers and allows the students to build useful programs quickly while learning the basics of structured and object-oriented programming techniques. The course is also aimed at developing the students programming and logic abilities. These two modules are prerequisites for all second-year programming modules.

METHOD

The data of 393 students who were enrolled for the two first-year courses between 2012 and 2015 were extracted from the university administrative system, and exported to a Microsoft Excel format. The variables that were extracted were student number, year of enrolment, final year of schooling results for all school subjects, and performance in the two first-year level programming courses. The data were scrutinised for anomalies, and cases were removed where data were incomplete, where students dropped out, or where students were refused admission to the final examination for not complying with minimum pre-examination performance criteria. A correlational analysis between the performances in the two programmes among the four year groups found that the year of enrolment did not significantly influence the correlations that were computed between 'performance in school mathematics', and 'performance in the two first-year level programming courses'. Therefore, the enrolment across the four cohorts was treated as a single data set.[3] No other contextual variables were identified that may have impacted on the performance in the two courses. The courses were taught by the same lecturer, using the same curriculum, and the same pedagogy. Assessment practices are standard, and the examinations are internationally benchmarked. The department admitted students to the programme who did mathematical literacy as a school subject and for which they achieved 70% or higher. Students who were admitted based on their school mathematics marks (n=274) outnumbered students who were admitted based on their mathematical literacy marks (n=119).

All the guidelines prescribed by relevant ethics committees were adhered to and permission was granted to conduct the research by the Faculty of Education Ethics Committee. During the research, utmost care was taken to ensure that data were recorded and analysed as accurately as possible. Only student numbers were used to identify respondents in order to ensure student anonymity and to assist the researchers in obtaining information about their performance in their programming modules, which was essential for the research. No personal interactions took place with students.

RESULTS

SPSS V.22 was used to perform the analyses. The following variables were used for analysis: 'school mathematics mark', 'school mathematical literacy mark', 'DevSoftware 1A performance' and 'DevSoftware 1B performance'. We created two additional dichotomous variables 'Mathematics –Yes/No', and 'Mathematical Literacy –Yes/No' to isolate students who were admitted with mathematics as a school

3 The 2015 dataset contains data for Software Development 1A only.

subject to the programme, as opposed to those who were admitted with mathematical literacy. Table 5 tabulates the combined descriptive statistics for these variables across the four cohorts.

Table 5:
Combined descriptive statistics for variables

	n	Min	Max	Mean	SD	Skewness		Kurtosis	
						Statistic	Std. Error	Statistic	Std. Error
DevSoftware 1A	361	29	91	59.53	11.356	.250	.128	-.109	.256
DevSoftware 1B	219	29	92	64.68	12.361	-.143	.164	-.381	.327
School Mathematics	274	16	80	48.98	9.165	.658	.147	1.766	.293
School Math Literacy	104	41	97	74.58	7.536	-.585	.237	3.562	.469

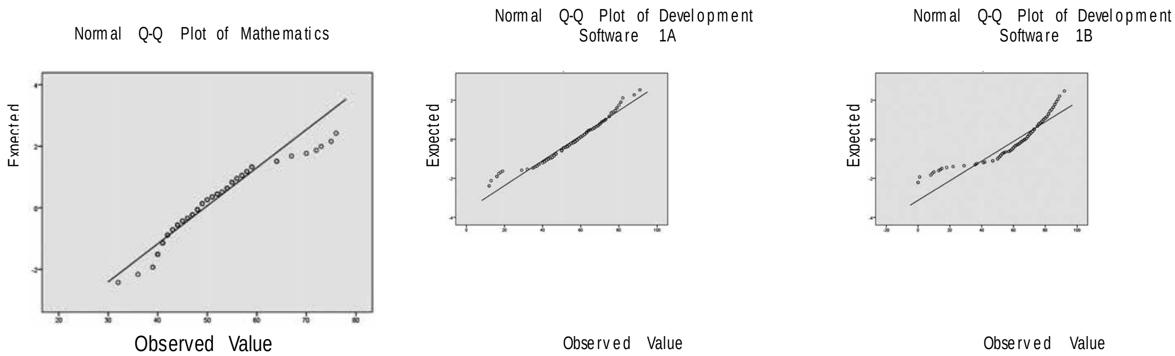
Table 5 shows that students performed better in Development Software 1B (M = 64.68) than they did in Development Software 1A (M = 59.53). This could partially be accounted for by students who dropped out due to poor performance in the first semester course, and whose marks brought the mean down. There were noticeably fewer students enrolled for the Development Software 1B course. There is also significantly less variation in the data for the 'school mathematics mark' (SD = 9.16) and 'school mathematical literacy mark' (SD = 7.53) variables than there is for 'DevSoftware 1A performance' (SD = 11.35) and 'DevSoftware 1B performance' (SD=12.36). The smaller variances for the school marks based variables can partially be explained by the admission requirements to the programmes, eliminating data points below 40% (for mathematics) and 70% (for mathematical literacy) that are required for admission to the programme. Table 6 tabulates the means for each variable by cohort.

Table 6:
Combined descriptive statistics for variables by cohort

	2012			2013			2014			2015		
	n	Mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
DevSoftware 1A	74	58.72	13.82	86	58.51	8.666	120	60.29	10.02	81	60.21	13.17
DevSoftware 1B	56	68.95	9.70	67	56.67	11.380	96	67.77	11.85	.	.	.
School Mathematics	61	48.62	9.18	60	49.03	8.602	100	48.28	8.88	53	50.64	10.27
School Math Literacy	31	73.03	10.00	24	76.83	5.577	32	74.25	7.14	17	74.82	4.667

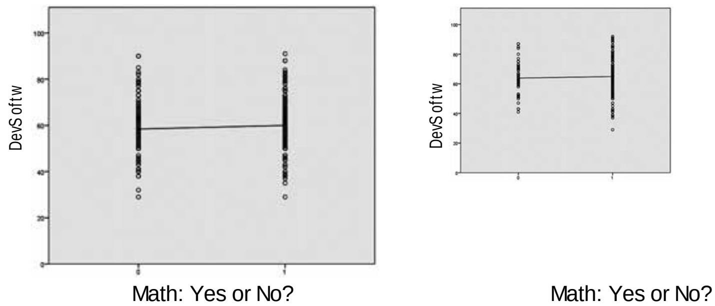
In order to establish the normality of the data, we decided to perform a visual inspection of the distribution of the data for three variables by generating Q-Q plots (quantile-quantile plots) for each variable: 'school mathematics mark', 'DevSoftware 1A performance' and 'DevSoftware 1B performance'. These are represented in Figure 1. It is immediately apparent that none of the data for any of the three variables could not be considered as being normally distributed.

Figure 1:
Q-Q plots of normality for each variable



A point-biserial correlational analysis was computed between each of the dependent performance variables and the variable 'Mathematics –Yes/No', which indicated whether having a 'school mathematics mark' correlated with performance in the two programming modules. The results revealed that having 'school mathematics mark' slightly correlates with 'DevSoftware 1A performance' and is not significant at the 0.05 level (r = .063, p > .05). A similarly weak correlation exists between having a 'school mathematics mark' and 'DevSoftware 1B performance', which was not significant (r = .038, p > .05). Based on these results, we can state that there is a weak relationship between having a 'school mathematics mark' and performance in either of the two modules. Figure 2 illustrates these weak correlations.

Figure 2:
Point-biserial correlational analysis between each of the dependent performance variables and the variable 'Mathematics –Yes/No',



The weak correlations revealed by the point-biserial correlational analysis between having mathematics as a school subject and performance in the two programming modules was surprising. We computed another dichotomous variable, 'Mathematics Literacy –Yes/No'. This variable was correlated against performance in the two programming modules. The results of this analysis is tabulated in Table 7.

Table 7:
Point-biserial correlational analysis between Mathematical Literacy and Development Software 1A and Development Software 1B

		DevSoftware 1A	Math Literacy Yes or No?	DevSoftware 1B
DevSoftware 1A	Pearson Correlation	1	-.130*	.610**
	Sig.(2-tailed)		.014	.000

	N	361	361	219

		DevSoftware 1A	Math Literacy Yes or No?	DevSoftware 1B
Math Literacy Yes or No?	Pearson Correlation	-.130*	1	-.038
	Sig.(2-tailed)	.014		.579
	N	361	393	219
DevSoftware 1B	Pearson Correlation	.610**	-.038	1
	Sig.(2-tailed)	.000	.579	
	N	219	219	219

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The point-biserial correlational analysis yielded a strong positive correlation between having mathematical literacy and performance in Development Software 1B which was significant at the 0.01 level (r = .610, p < 000), whereas a slight negative correlation, yet significant at the 0.05 level was found to exist between having mathematical literacy and performance in Development Software 1B (r = -.130, p < 000).

We further computed the correlation between the variables 'school mathematics mark' and performance in each of the two programming courses. The results of these analyses are tabulated in Table 8 and Table 9.

Table 8:
Correlation between Mathematics and Development Software 1A

		Mathematics	Development Software 1A
School Mathematics Mark	Pearson Correlation	1	.129
	Sig.(2-tailed)		.157
	N	129	123
Development Software 1A	Pearson Correlation	.129	1
	Sig.(2-tailed)	.157	
	N	123	123

It is evident from Table 8 that for the students who enrolled for SoftDev1A, a weak, insignificant correlation (r = .129, p > 05) exists between the marks obtained in mathematics in high school and performance in thecourse.

Table 9:
Correlation between Mathematics and Development Software 1B

		Development Software 1B	Mathematics
Development Software 1B	Pearson Correlation	1	.153
	Sig.(2-tailed)		.113
	N	108	108

		Development Software 1B	Mathematics
Mathematics	Pearson Correlation	.153	1
	Sig.(2-tailed)	.113	
	N	108	129

It is evident from Table 9 that, for the students who enrolled for SoftDev1A, a weak, statistically non-significant correlation ($r = .153$, $p > 05$) exists between the marks obtained in mathematics in high school and performance in the course.

DISCUSSION AND CONCLUSION

The very notion that performance in mathematics at the school level can be correlated with performance in mathematics in HEIs is being re-examined internationally. For example, at the University of Limerick in Ireland, 31% of students who obtained distinctions in mathematics at the Leaving Certificate level, were diagnosed as being 'at-risk' in their higher mathematics courses. This points to international discrepancies between students' school-leaving mathematics examination results and mathematics comprehension post-school. This trend has been observed in the United Kingdom, Australia, the United States of America and in Ireland (Hourigan & O'Donoghue, 2007). In South Africa, a study by Maharaj & Gokal (2006) showed that there was no correlation between students' Grade 12 mathematics results and their performance in first-year Information Systems and Technology courses. Clearly a substantial discord exists between school leaving abilities in mathematics, and expected performance at the HEI level.

Therefore, it is not surprising that the findings of our study indicate that mathematics marks at the school level, in this context, could not be correlated with performance in programming courses at the university level at levels of significance. These results contrast those of Byrne & Lyons, (2001), Wilson & Shrock (2001), Gomes & Mendes (2008), and Bergin & Reilly (2005) who claimed that performance in mathematics can predict programming performance. This finding places the very notion of using school level exit marks as a criterion for admittance to university programmes in South Africa under the spotlight. It is important to note here that we are not claiming that ability in mathematics does not correlate with success in programming courses. Our position is that the mark that is used to express mathematical ability does not correlate with performance in programming courses. Therefore, the validity of the mark as being reflective of mathematical ability is questioned!

The majority of the students whose performance data were used in this research, were not required to complete the NBTs in order to acquire access to the NDIT. It will be useful when the requirement to complete NBT assessment is established and mandatory, to re-examine the relationship between those results and performance.

Language ability also plays a significant role in acquiring programming skills, and it may very well be that language and language comprehension ability may play a role here. The South African NBTs, may possibly be more accurate predictors of performance in programming courses, and research needs to be conducted on potential students and their NBT results in an attempt to determine a student's success in programming courses.

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