EXAMINING THE CORRELATION BETWEEN EDUCATIONAL BACKGROUND AND ACADEMIC PERFORMANCE OF FIRST YEAR COMPUTER PROGRAMMING STUDENT'S IN SOUTH AFRICA

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Abstract

The aim of this study is to establish what correlational relationship exists between a student's educational background as determined by his or her critical thinking and self-regulation skills and academic performance in first-year level programming courses. The student's achievement in the programming courses is specified as the dependent variable. A student's educational background is specified as the independent variable. The study group consists of 379 students studying Information Technology at the University of Johannesburg, Johannesburg and the Tshwane University of Technology, Pretoria in South Africa. No correlation was found between a first year computer programming student's educational background and performance in programming.

Introduction

In South Africa there are many indications that there is a crisis in the education system (Modisaotsile, 2012). Newspaper Headlines like: "Teachers in Court over Fake Qualifications," "Cape Schools Allowed to Fall into Ultimate Decay," "Maths Teachers Sums Don't Add Up," "KZN Matrics Still Lacking Textbooks," "SA Teachers Can't Teach," "Alarm Over AWOL Teachers," and "Teachers Not Coping with Overcrowding" – shows that the education system remains largely in a poor state of affairs. Poor communities, specifically those from rural areas, bear the brunt of the past inequalities (Moletsane, 2012). Prior to 1994, education in South Africa was designed to privilege whites and disadvantage blacks. It has been 24 years since the end of apartheid in the country, and although South Africa has one of the highest education budgets in the world and spends a larger portion of its budget on education than the United States and United Kingdom (Cohen, 2017), the inequality of the education system still propagates. As a result, the South African schooling system is failing to provide higher education institutions with students that can cope with the jump from high school to university (Moutan, Louw, & Strydom, 2013).

With the transition from high school to university already being problematic, Information Technology (IT) students also find the subject computer programming difficult. The competencies required for success in computer programming are: (a) logical reasoning – which is a student's ability to think logically and analytically; (b) non-verbal reasoning – which enables students to analyse and solve complex problems without relying upon or being limited by language skills (e.g., identifying relationships, similarities and differences

between shapes and patterns, recognizing visual sequences and relationships between objects, and remembering these); (c) numerical reasoning – mathematics; and (d) verbal logic – which is a students' ability to extract meaning from complex information and problem solve (University of Kent, 2017). These skills however, are not being taught in the South African educational system.

Mapping South Africa's Educational Background

The prevalence of poverty in townships and rural areas is reflected in the schools within these communities. There are many problems that South African township and rural schools face, the most common of them being a lack of basic facilities such as water, electricity and toilets, poor provision of educational resources such as textbooks, a shortage of classrooms resulting in overcrowding, poor quality of teachers, a shortage of mathematics and science teachers and the learners themselves.

Lack of Facilities

Poor facilities in most schools, but especially rural areas, is commonly cited as a factor contributing towards the poor performance of learners (Hugo, Jack, Wedekind, & Wilson, 2010). Many rural schools in South Africa endure what can only be described as appalling circumstances. As Draga (2017, p.238) describes, "Crumbling classrooms, horrendous bathrooms, cracked fences and non-existent libraries and laboratories remain a reality for thousands of school-going children across South Africa." Examples of the state of disrepair in rural schools abound: Tsakani Primary School in Kagiso on the West Rand, do not have enough chairs, desks and other learning materials for their learners (Dipa, 2015). There are approximately 40 learners in a classroom and many of them have to share desks and chairs due to a shortage. At the Glen Primary School in Port Elizabeth learners sit on a cold concrete floor (Sobuwa, 2017). An audit conducted in 2015, on hygiene, at approximately 200 Gauteng government schools revealed that schools have on average 100 learners to one toilet (Wicks, 2015). At the Lufhereng Secondary School in Soweto a "45m electrical cable runs through the principal's office door, across the schoolyard, over a street, down a side alley and through a window, finally connecting to a plug in the tiny kitchen of a four-roomed RDP house" (Macupe, 2017, p.1). Statistics released by the Department of Basic Education (DBE), state that 22% of government schools have either untrustworthy water or no water and 15% have untrustworthy electricity or no electricity (Motsepe, 2016). Twenty-four years into democracy this is inconceivable.

Poor Educational Resources

The problem regarding unequal distribution of resources is still commonplace. Text books are considered significant resources for learners' reading and writing development. Just two weeks before the matrics wrote their final exams in 2017, English textbooks were still in short supply at some KwaZulu Natal schools (Wolhuter, 2017). Not only are textbooks in short supply, but also some schools do not allow their learners to take textbooks home, which obstructs learning, especially in rural schools where this practice is most prevalent. De Vos (2018, p.1), rightly asks "Why should some learners be

able to work from textbooks at home and others not?" To add fuel to the fire, 77% of South African schools have no libraries and 86% have no computer laboratories (DGMT, 2015).

Overcrowded Classrooms

Research has shown that smaller classrooms result in an overall improvement in reading and mathematics especially in the earlier grades. Small classes are especially beneficial to learners from low socio-economic families and those whose first language is not English (Howie, 2003). Overcrowding has a negative impact on teaching and learning as learners do not get to engage one-on-one with their teachers. Learners who are struggling with certain concepts get lost in the system. Many teachers who work in overcrowded classrooms have low morale and self-esteem. Large classrooms are also not conducive to dynamic teaching strategies (Marais, 2016). The South African Government stipulates that there should be no more than 35 learners to a classroom (Department of Basic Education, 2013, p. 55). However, according to the Cape Argus (Tswanya & Hlati, 2017), Solomon Qatyana Primary School in the Strand has a ratio of 1 teacher to 46 learners and at Tinley Manor Primary School near KwaDukuza some classes have up to 120 learners (Shaikh & Msomi, 2018).

Qualifications of Teachers

The South African Council of Educators (SACE) reported in 2016 that hundreds of teachers had been found to have fraudulent teaching qualifications and were dismissed as a result (Maromo, 2016). The plight of teachers being unqualified (have a Grade 12 certificate and are in the process of studying for a teaching qualification) and underqualified (have a degree but not a teaching qualification) in South Africa is real (Jansen, 2015). According to the Department of Basic Education, schools currently have over 5000 underqualified or unqualified teachers (Phakathi, 2017). The reality is that due to the shortage of teachers in South Africa, the DBE has its hands tied. Additionally, there is a high absenteeism rate amongst teachers (Ndaba, 2017) especially in the poorest quintiles in South Africa. The Centre for Development and Enterprise (CDE) Executive Director, Anne Bernstein, agrees that teachers do not spend enough time in the classroom and when they do they are not active (CDE, 2011). Teachers who are regularly late and absent not only form a poor learning environment but also lull a learner into adopting apathetic learning habits and a passive outlook towards their own future (Taylor, 2008). In the teachers defence, the National Professional Teachers Association (NAPTOSA) Executive Director, Basil Manuel, says that teachers are overworked due to the overcrowding in the classrooms leading teachers to being burnt out and therefore absent (Ndaba, 2017).

Shortage of Mathematics and Science Teachers

The CDE recently reported that not enough teachers are graduating in South Africa, especially in the subjects of mathematics and science. "Teacher shortages, especially in gateway subjects such as maths and science, are seen as a key contributor to SA's poor educational outcomes" (Gumede, 2017, p.1). The teaching system is producing only a third of South Africa's requirement of about 25 000 new teachers a year (CDE, 2011) and only a few teachers

graduate in mathematics and science. The challenge for the Department of Education is emanated 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 lack (Jacobs, 2013).

Literature Review

Research shows that the type of high school a university student attended directly affects their academic performance (Ali, Haider, Munir, Khan, & Ahmed, 2013; Birch & Miller, 2007). It is therefore assumed that a student who does well in high school will also do well at university, however, many researchers argue this point. Considine and Zappala state that the high school environment as well as a teacher's expectations of a learner, sets the boundaries to learning (2002). Thus, if a student attended a decent school, offering smaller classes with qualified teachers who gave individual attention and participated in extra mural activities, these students would perform better academically than students who attended the schools mentioned above.

The Programme for International Student Assessment (PISA) (OECD, 2010), however, believes that many disadvantaged students achieve well above what is predicted as do a proportion of students from privileged backgrounds perform below what is predicted. For any group of students there is a range in performance. This can be considered as a phenomenon named *educational resilience* (Pedrosa, Dachs, Maia, Andrade, & Carvalho, 2006). Yorke and Longden (2004), Cleyle and Philpott (2012), and Toni and Olivier (2004) concede that students can become committed to making a positive change in their lives and commit to their university studies by using their challenging circumstances as an incentive. What high school factors then affect a student's success in university? According to Vermunt and Verloop (1999), one of the goals of teaching is for a student to master independent learning skills such as critical thinking and self-regulation.

Critical Thinking

Critical thinking is one of the most important mental tools that learners must have to become competent computer programmers, as problem solving forms the foundation on which computer programming is built (deRaadt, 2008). Research indicates that very few students are able to engage with and solve programming problems that involve critical thinking (Gomes & Mendes, 2007). Critical thinking is directly related to academic achievement (Cevik, 2013) as students who have critical thinking skills on a higher level are more likely to achieve academically than students who have critical thinking skills on a lower level (Akbıyık & Seferoğlu, 2006). It is thus imperative that high school teachers teach students to ask questions, problem solve, analyse ideas and think critically. To make this happen, teachers themselves have to possess these skills in order to transfer the learning (Karagöl & Bekmezci, 2015). It is, however, questionable that these skills are being taught in all South African schools.

Self Regulation

Self-regulated learning is a process that assists students to better manage their thoughts, their behaviour and emotions with the aim to successfully navigate their learning experiences (Zumbrunn, Tadlock, & Robert, 2011). Self-regulation is an important predictor of achievement at university (Zimmerman, Bandura, & Martinez-Pons, 1992). University students need to be self-directed in their studies, continuously monitoring their learning and self-reflecting on their progress (Zimmerman & Schunk, 2008). At high school, a limited amount of self-regulation is required for learners to achieve, as teachers and parents constantly remind and guide learners to complete their homework and assignments, assist the learners with preparing for tests and give constant motivation and feedback on the learners' progress. Whereas at university, students are expected to motivate themselves and develop their own goals and learning strategies: "University requires students be proactive and self-disciplined and engage in self-creation, self-initiation and self-evaluation of academic tasks" (Bembenutty, 2011, p.5). However, many university students lack the ability to self-regulate and struggle to set academic goals for themselves. Students find it difficult to identify appropriate learning strategies and therefore start off their academic journey at a disadvantage (Bembenutty, 2011).

Many of the students who enrol for the National Diploma Business Information Technology at the University of Johannesburg and the National Diploma Information Technology at the University of Pretoria where this study was conducted originate from former "black schools" that were beset with the problems described above. This may offer possible explanations for the poorly developed skills of students who at universities struggle to cope with the demands of higher learning.

Context of the Study

Performance in computer programming modules at Higher Education Institutions (HEIs) has traditionally been low. Within the context of world-wide shortages of skilled programmers, it becomes imperative that greater success is achieved in HEIs. 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 courses. In the quest for identifying those attributes that may have an impact on student success in the programming modules, the research question asked was:

Is there a relationship between a novice South African programming student's educational background as determined by their critical thinking skills and self-regulatory skills and their performance in programming modules?

Sub Question 1: Does a student's critical thinking ability affect their academic performance in computer programming?

Sub Question 2: Does a student's self-regulation ability affect their academic performance in computer programming?

Method

The participants of the study were a group of 186 first year students enrolled for the National Diploma Business Information Technology (NDBIT) at the University of Johannesburg (UJ) and 193 first year students enrolled for the National Diploma Information Technology (NDIT) at the Tshwane University of Technology (TUT).

Data collected consisted of a student profile questionnaire (SPQ) and examination results. The SPQ was piloted before being finalised. This questionnaire was completed by students during their first year of studying computer programming. The examination results were from the students' programming module, Development Software 1: UJ - Development Software 1A (DSW01A1) and Development Software 1B (DSW01B1); and TUT - Development Software 1A (DSO171AT) and Development Software 1B (DSO171BT). Student numbers were used as the key field to link the data sets. The Development Software 1 (DS1) results were used as the dependent variable throughout the study.

DataAnalysis

Students' educational background was determined by them being encouraged to think critically at school and their ability to self-regulate their learning.

Critical Thinking

The subscale contained items that attempted to establish the extent to which students believed that their critical thinking skills were developed at school. In order to statistically determine critical thinking encouragement at school, an exploratory factor analysis was used to identify different items. The critical thinking factors identified at school were: Factor 1 = study habits, Factor 2 = analysis, Factor 3 = encouraged to think independently. Factor 3 was discarded due to the Cronbach Alpha value being 5.88, an unacceptable inter-item correlation according to George and Mallery (2003, p. 231). The relationships and patterns within each remaining item were then correlated with the dependent variable DS1 mark.

Table 1

Correlation of Critical Thinking and DS1 Mark

Correlations		
		DS1 Mark
Factor 1 (at school) - Study habits	Pearson Correlation	-.098
	Sig. (2-tailed)	.057
	N	376
Factor 2 (at school) - Analysis	Pearson Correlation	.000
	Sig. (2-tailed)	.996
	N	377

A Pearson product-moment correlation coefficient was computed to assess the relationship between Factor 1: study habits variable and the students' performance in DS1 variable. There was no correlation between the two variables, r = -.098, n = 376, p = .057. The results show that for this group there is an insignificant correlation between students who were encouraged to develop good study habits at school and performance in DS1.

A Pearson product-moment correlation coefficient was computed to assess the relationship between Factor 2: analysis variable and the students' performance in DS1 variable. There was no correlation between the two variables, r = .000, n = 377, p = .996. The results show that for this group there is an insignificant correlation between students' who were encouraged to analyse their work at school and performance in DS1.

Self-Regulated Learning

The data indicated that the majority of students regulate their own learning experiences. In order to determine which self-regulated learning traits correlated with a student's success in their DS1 mark, exploratory factor analysis was used to identify different items. The self-regulation factors identified at school were: Factor 1 = metacognitive ability, Factor 2 = self-efficacy, Factor 3 = motivation to learn. The relationships and patterns within each item were then correlated with the dependent variable DS1 mark.

Table 2

Correlation of Self-Regulated Learning and DS1 Mark

Correlations		
		DS1 Mark
Factor 1 (self-regulated learning) metacognitive ability	Pearson Correlation	-.022
	Sig. (2-tailed)	.669
	N	370
Factor 2 (self-regulated learning) self-efficacy	Pearson Correlation	.055
	Sig. (2-tailed)	.292
	N	370
Factor 3 (self-regulated learning) motivation to learn	Pearson Correlation	-.119
	Sig. (2-tailed)	.022
	N	370

A Pearson product-moment correlation coefficient was computed to assess the relationship between Factor 1: metacognitive ability and the students' performance in DS1 variable. There was no correlation between the two variables, r = -.022, n = 370, p = .669. The results show that for this group there is an insignificant correlation between the students' metacognitive ability and performance in DS1.

A Pearson product-moment correlation coefficient was computed to assess the relationship between Factor 2: self-efficacy and the students' performance in DS1 variable. There was no correlation between the two variables, r = .055, n = 370, p = .292. The results show that for this group there is an insignificant correlation between the students' self-efficacy and performance in DS1.

A Pearson product-moment correlation coefficient was computed to assess the relationship between Factor 3: motivation to learn and the students' performance in DS1 variable. There was a medium, negative correlation between the two variables, $r = -.119$, $n = 370$, $p = .022$. Overall, there was a small inverse correlation between the students' motivation to learn and performance in DS1.

Discussion and Conclusion

The quality of the South African education system can be summarised 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 background of this study highlighted a lack of facilities, poor educational resources, overcrowded classrooms and a lack of qualified teachers as potential contributing factors of a learner's poor performance. Next, the high school factors that could affect a student's success at university namely, critical thinking and self-regulation were discussed. In order to determine if students were taught to think critically at school, they were asked a series of questions, for example, to what extent they were encouraged: to plan before attempting a task, to have an inquiring mind and to ask questions, to find multiple solutions to problems, to break a problem into different parts in order to solve it, etc. It is well known that students in high school are taught to rote learn rather than think critically. However, the students in the study, self-reported that their critical thinking skills were developed in high school. In this context though, a student being encouraged to think critically at school, could not be correlated with performance in programming modules at the university level. In order to determine if a student was able to self-regulate, students were asked a series of questions, for example, I believe I will do well in this course, I work hard at a task even though I don't like a task, I keep checking that I'm on the right track while I'm busy with a task, I plan first before I begin with a task, etc. In high school, a limited amount of self-regulation is required for learners to achieve, whereas at university, students are expected to motivate themselves and develop their own goals and learning strategies. In this context though, a student's self-regulation ability, could not be correlated with performance in programming modules at the university level.

This study forms part of a series of studies looking at the pre-entry attributes thought to influence the performance of students in computer programming. The pre-entry attributes in previous papers included problem solving ability, socio-economic status, performance in school mathematics, English language proficiency, digital literacy and previous programming experience (Barlow-Jones & van der Westhuizen, 2017). Many researchers (Ali et al., 2013; Birch & Miller, 2007; Considine & Zappala, 2002) state that the type of school a child attends influences his or her academic achievement at university. However, it could be concluded, in this study, that educational background did not predict academic achievement in computer programming in a higher education institution.

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