PERFORMANCE, PROFICIENCY AND LANGUAGE: EXPLORING FACTORS CONTRIBUTING TO SECOND-LANGUAGE STUDENTS' EXCELLENCE IN MATHEMATICS

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ABSTRACT-Literature suggests that teaching and learning mathematics through a second language (L2) is daunting. In South Africa, learning mathematics through English L2 is identified as the root cause of L2 students' underperformance in this subject, partly because mathematics requires more specialized jargon that may not be available in L2 students' home language. Nonetheless, some L2 students excel in mathematics and sometimes even outperform their English first-language counterparts. Yet little research explains this phenomenon. This qualitative case study investigated student teachers' perceptions of factors contributing to their excellence in mathematics offered in undergraduate Bachelor of Education programmes in a South African university. The research question was: What do African L2 student teachers perceive as factors contributing to their excellence in mathematics? Data were collected through a questionnaire and interviews and triangulated with students' academic records, followed by thematic data analysis. Participants included eleven African student teachers and three mathematics graduates. Participants' views differed on the contribution of language to their excellence in mathematics. Some participants perceived human agency as vital to their excellence. These results provide a fresh, positive and different perspective on research in mathematics, as they illustrate that African students have unique within-individual capacities to excel in this subject.

Keyword: Language; Performance; Proficiency.

1. INTRODUCTION

Nationally and internationally, research has shown that teaching and learning mathematics through a second language (L2) is challenging, leading to poor achievement among L2 students who study this subject (Ball, Goffney & Bass, 2005; Barwell, 2010; Gerber, 2005; Gerber, Engelbrecht, Harding & Rogan, 2005; Winsor, 2007, 2008). Ball et al. (2005) maintain that disparities in mathematics achievement continue to be tightly coupled with social class and race. Other research on L2 students' poor performance in mathematics points to teaching strategies that do not cater to their needs, as well as teachers' poor content knowledge (Howie, 2003; Mji & Makgatho, 2006). Some authors have shown that it is difficult for students to understand abstract concepts and ideas in mathematics and science subjects, especially if they are not presented in home language (L1) (Gerber, 2005; Gerber, Engelbrecht, Harding & Rogan, 2005; Winsor, 2007, 2008). Like all disciplines, mathematics has a specific, technical jargon related to it as a discipline that both L1 and L2 students who study this subject have to master. This register allows them to speak, read and write like seasoned mathematicians (Ernst-Slavit & Slavit, 2007; Setati, 2002). That mathematics is a 'language' in its own right (Usiskin, 1996, cited in Setati, 2005) complicates the mastery of this subject for all students, but more especially for L2 students. A number of studies point to L2 learning as the root cause of students' underperformance in mathematics (Howie, 2003; Kahn, 2005; Setati, 2002, 2008; Yushau, 2009). For example, Kahn's (2005) analysis revealed that it is predominantly L2 learners who perform poorly in Grade 12 mathematics. Similarly, Howie (2003), referring to the 3rd International Mathematics and Science Study (TIMMS), drew the same conclusion about low proficiency and L2 learning.

South Africa has participated in four TIMMS assessments in 1995 and 1999 (Grade 8); 2002 (Grade 8 and 9) and 2011 (Grade 9). A total of 11 969 learners participated in TIMMS 2011 (Reddy, Zuze, Visser, Winnaar and others, 2015). Data from these assessments reveal an increased Grade 9 performance

trajectory of over 60 points between 2002 and 2011 in mathematics and science (Reddy et al., 2015). Reddy, Prinsloo, Arends, Visser and others (2012) report an average national score increase of 63 points in mathematics and of 60 points in science. However, approximately 90 per cent of South African learners achieved an average score of 352 out of a possible 1000 points, which was well below the international benchmark of 500 midpoint score (Mullis, Martin, Foy & Arora, 2012). This translates to approximately 10 772 of 11 969 South African learners who scored below this average midpoint score, notwithstanding that these Grade 9s, along with those from Botswana and Honduras, were tested in Grade 8 TIMMS and thus competing against Grade 8 learners from other countries. Grade 8 learners from all the participating countries except Ghana outperformed South African Grade 9 learners who participated in TIMMS 2011. This placed South Africa at the bottom six of the 63 countries participating in TIMMS (Visser, Juan & Feza, 2015). Of grave concern was that the variation in TIMMS assessment scores remained extremely high among South African learners from different racial and socio-economic backgrounds, suggesting unequal experiences and wide disparities among learners in this country. These disparities emanate not only from L2 teaching and learning, but from several other factors. They include socio-economic status of a school (e.g. resources, teachers' qualifications) (Spaull, 2013; Van der Berg, 2008); home language and class size (Howie, 2003) and home socio-economic status (Sirin, 2005; Olatunde, 2010). Due to the discrepancies that exist among South African learners, Reddy, Juan and Meyiwa (2015) refer to South Africa as having two education systems- a well performing (30%) alongside an underperforming (70%) system.

While abundant literature on the negative effect of L2 on mathematics learning and teaching and on L2 students' underperformance in this subject exists in South Africa and elsewhere, little research has investigated the factors that explain why some L2 students excel in this subject despite the linguistic challenges involved. Visser, Juan and Feza (2015) have identified home and school socio-economic status, class size, teaching and test language and utilisation of computer software to supplement mathematics instruction as predictors of mathematics performance in South Africa. However, their study did not zoom on a specific group of learners in terms of race and level of study. The study reported in this paper investigated the factors that contribute to African student teachers' excellence in mathematics offered through the medium of English L2 in the undergraduate Bachelor of Education (BEd) teacher education programmes (TEPs) in a selected South African university. The research question was: What factors contribute to the African student teachers' excellence in mathematics taught through English L2 medium? In this study, excellence in mathematics refers to a continuous achievement of 75% or more in mathematics maintained by a student from first to final year of study. Only African-language speaking students were selected as participants in this study. This study adds to existing knowledge on L2 students' excellence in mathematics, which is an area that has not yet been widely researched in South Africa.

2. CONTEXT OF THE STUDY

The setting of this study was a Faculty of Education at a university situated in the Western Cape Province. This Faculty offers initial teacher education programmes at the Foundation Phase (FP) (Grades R-3), Intermediate and Senior Phase (ISP) (Grades 4-9) and the Further Education and Training band (FET) (which spans Grades 10-12 and the Technical Vocational Education and Training (TVET) sector). Teacher education programmes are offered at the Bachelor of Education (BEd) degree level which is pegged at Level 7 of the National Qualifications Framework (NQF). Two major streams are offered in the FET TEPs: the Commercial Stream (Accounting, Economics, Business Management, Mathematics, Mathematical Literacy and Computer Application Technology) and Science stream (Mathematics, Mathematical Literacy, Physical Science, Biology, Computer Science and Languages [English, Afrikaans and the African language of the region]). Students choose a minimum of two major subjects from either the commercial or science stream in which they are enrolled. Mathematics curriculum, which is optional in both streams, covers content-, pedagogical- and pedagogical-content teacher knowledge domains. It is from these two teacher education programmes that the participants for this study were selected.

The FET TEPs are offered on two campuses, one in which the medium of instruction is English and the other Afrikaans. Therefore, Afrikaans- and English speaking students have a choice to attend the Afrikaans- or English medium TEP. For African students, however, both English and Afrikaans are L2s. In the TEPs where this study was conducted, English was the medium of instruction, implying that language privileges some students and hinders others.

3. LITERATURE REVIEW

Internationally, criticism has been and continues to be levelled against teaching and learning through L2 in school and university classrooms due to the negative effects it has on L2 students' academic achievement (Alexander, 2006; Ong & May, 2008) and the challenge it creates for teachers and learners (Angateeah, Hurchand, Sukon & Nunkoo-Gonpot, 2013; Skutnabb-Kangas & Dunbar, 2010). Skutnabb-Kangas and Dunbar (2010, p. 11) assert that imposing a dominant language such as English as LoLT creates barriers to learning because of the 'linguistic, pedagogical and psychological barriers it creates' for learners. While these concerns pertain to teaching and learning in L2 in general, when it relates to L2 mathematics teaching and learning, such concerns become more intense. Ong and May (2008) confirm this assertion, mentioning that L2 learners encounter difficulty in interpreting the meaning of mathematics discourse.

Naudé, Engelbrecht, Harding and Rogan (2005) contend that it is globally acknowledged that when learning mathematics in multilingual societies, some students learn mathematics through a L2 or third language (L3), which presents a challenge for them. As indicated earlier, this is because mathematics has special conventions, signs and symbols, and patterns with which students in general, and L2 students specifically, are unfamiliar. As such, before L2 learners can understand mathematical English register, they first have to understand spoken English. Botes and Mji (2010) and Gerber et al. (2005) support this assertion, claiming that when teaching mathematics or mathematics concepts, L2 learners are exposed to two languages simultaneously, as explanations are made in one language (spoken language) to clarify the specific language used in mathematics. Over and above these different languages, students still have to master the mathematics content. Yushau (2009, p. 918) puts it succinctly, that 'there is the double task for (L2) learners, the acquisition of two conceptually difficult and different skills at once, one being related to language and the other to mathematical content'. Over and above this, as shown in discussion of the theory, L2 students still have to master communicative competence in the classroom.

To emphasise this complexity, Setati (2005, p. 448) claims that learning mathematics denotes 'acquiring fluency in the language of mathematics [mathematics language] which includes words; phrases; symbols; abbreviations; and ways of speaking reading, writing, and arguing that are specific to mathematics'. As highlighted earlier, Setati (2002, 2005) acknowledges the challenges faced by L2 students emanating from the fact that mathematical English is blended with spoken English, requiring students to be proficient in both areas. Barwell (2003, p. 38) maintains that 'native speakers of the classroom language have some degree of advantage, as compared with fellow students who are still learning the language of teaching and learning'. According to Ernst-Slavit and Slavit (2007: 23), 'various discourse and syntactical features [embedded in the mathematics register] can make it difficult for speakers of different English varieties or ELLs to draw meaning from mathematical learning environments'. These assertions point to the fact that language is a cultural capital, which may unfairly advantage or disadvantage students, depending on their habitus. They show that those students with English habitus are better predisposed to understand the discipline of mathematics than those who are not predisposed to this cultural capital. While some studies have attempted to address the factors that explain mathematics achievement among learners in general, none has zoomed on the factors that contribute to the excellence of African student teachers in this subject despite their limited predisposition to English linguistic capital. This is what this study sought to uncover.

4. METHODOLOGY

The design of this qualitative study was a case study of 14 participants selected from the BEd FET teacher education programmes in the Faculty of Education at a university in the Western Cape Province. The sampling procedure was primarily purposive. The first cohort comprised 11 second to fourth-year BEd-FET African-language speaking student teachers who had maintained a distinction in mathematics in the BEd levels prior to and for which they were enrolled. The second cohort consisted of three (3) recent African-language speaking graduates who had maintained a distinction in mathematics throughout the four BEd levels and had graduated within the past two years (2014 and 2015). All the participants (had) studied mathematics through English L2. First-year, as well as Afrikaans and English home-speaking students were excluded from the study. Three criteria were used to select participants: (i) they had obtained a distinction (75-100%) in mathematics content throughout their current and previous years of BEd FET study; (ii) If they were fourth year students or graduates, they had maintained that score from first to fourth year of study; and, (iii) their L1 was an African language. Since the researcher coordinated the fourth-year Commercial-Stream BEd-FET programme and kept students' academic records during and after they had graduated, she purposely selected the sample from these two groups using these records. However, with regard to the fourth-year students in the Science-Stream and those in the other BEd FET study levels in both streams, the researcher requested mathematics lecturers to identify African-language speaking students who had maintained a distinction in mathematics in the respective study levels. Mathematics lecturers furnished her with this information. Extraneous factors, including students' previous attendance at an English-medium high school or being raised by an English-speaking family were not controlled for, although cognisance was taken that they could be mediating factors on their excellence in mathematics.

Data were collected using semi-structured, open-ended individual interviews with students currently enrolled in the teacher education programmes, with each lasting for approximately 30 minutes. Since the three graduates had already left the university and were difficult to reach physically, open-ended questionnaires were sent to them using *Whatsapp* and Facebook Messenger, with a 100% response rate. Both data-collection instruments were developed by the researcher based on the purpose of this study and the research question for which answers were sought. Questions in both instruments were similar. They solicited information regarding the effect of English language on mathematics acquisition and factors contributing to excellence in mathematics. During the interviews, the researcher probed for further explanations from participants, which she could not do with the questionnaires. An expert on research in teacher education tested both data-collection instruments for validity and reliability. The researcher triangulated data obtained from participants using students' academic performance records. Participants' lecturers were also consulted to testify about participants' performance in this subject. Permission to use students' records was solicited from the heads of departments (HODs) in the commercial and science streams, mathematics lecturers and students. Ethical clearance was obtained from the university's Ethics Committee. A digital voice recorder was used to record the interview responses after the researcher had obtained verbal consent from participants to participate in the study and to use the recording device. The researcher explained verbally and in writing ethical considerations relating to voluntariness, confidentiality and anonymity before participants participated in the study. All the participants signed the consent forms. Pseudonyms were used to conceal the real names of participants. After the interviews were transcribed, data from interviews and questionnaires were analysed individually using different colour codes to highlight similar and different emerging themes. The researcher synchronised and merged emergent themes from both instruments, and constantly compared them with those on the academic records. She then grouped and classified the highlighted themes from the instruments, and later used emergent themes as subheadings that are presented in the next section.

5. RESULTS

The results presented in this section represent the themes that emerged from the responses of the 14 participants who participated in the interviews and questionnaires. As indicated earlier, pseudonyms were used in order to conceal their identity.

The influence of language on students' mathematics performance

In this study, the participants' debate centred on whether or not the use of L2 language in the classroom had an impact on African students' understanding of mathematics (Howie, 2003; Nicol & Crespo, 2005; Matang, 2006; Setati & Barwell, 2006; Feza-Piyose, 2012) and whether it affected their performance in this subject. Results revealed that some participants did not perceive a relationship between these variables. Simba, a BEd second-year male participant in the Science Stream did not seem to perceive the influence and effect of language on understanding and excellence in mathematics, arguing that:

You can be fluent in English but still struggle with mathematics content, or not be an English speaker but excel in mathematics.

Ntsika, a third-year male participant in the Commercial Stream, also dispelled the notion of language as a contributing factor to excellence in mathematics, contending that,

Maths is not about English or Afrikaans or XY [an African language] but it's about understanding and logic. If language was a barrier, my maths marks would not be as high as they are. In class there are English speakers who struggle just like second-language students.

These perceptions challenge the widely taken-for-granted assumptions about the role of language on mathematics teaching and learning. They do, however, confirm the argument held by Setati and Barwell (2008), that poor performance in mathematics among L2 students cannot solely be attributed to the language. Participants in this study speak an African L1 as home language. Therefore, they are not predisposed to English language but they still excel in mathematics which is taught in L2. Under the circumstances, one can acknowledge that other factors other than language affect mathematics acquisition and performance, as shown earlier in the literature (Sirin, 2005; Van der Berg, 2008; Olatunde, 2010; Spaul, 2013; Visser, Juan & Feza, 2015).

Nonetheless, not all the participants dismissed the role played by linguistic capital in their excellence in mathematics. Dali, a male participant who had recently graduated from the Commercial Stream, averred:

The most outstanding factor that has contributed to my excelling in maths, and I still believe is a major contributor, was my very early understanding of the English language. Reading large volumes … helped me to make sense of the English language. If one understands the 'language of the Queen' [English], it becomes easier to read and understand the core of any maths problem.

Zukiswa, a third-year female participant in the Science Stream who had obtained her primary and secondary education from an English-medium school, reiterated Dali's statement, emphasising that,

Language is a very important factor towards performing well in maths. Not that language is the only barrier to learning maths for some, but it helped a lot that I did my Grades 8-12 in an English medium high school where teachers only spoke English. I was able to answer the maths exam questions especially in those aspects that required language comprehension.

Dali and Zukiswa might have assimilated and internalised the cultural capital of the dominant society. They believe that early exposure to English facilitated and contributed to their excellence in mathematics. It is difficult to accept these convictions at face value, as they disregard internal and

external variables (e.g. high motivation, support structures, compatibility between teaching and learning styles and quality of teaching, and socio-economic factors) that might have contributed to excellence. These assertions do confirm the perspective held by some, that proficiency in English translates into improved learner performance in mathematics (Howie, 2003). However, debate still rages over this issue, with others believing that English, while necessary, is not the single decisive factor to account for improved performance in mathematics (Setati, 2008). In fact, Setati (2008, p. 113) contends that 'Quality mathematics teaching and learning involves much more than fluency in the LoLT (in this case English)'. Therefore, in this section, data obtained from students present further controversy on the role of language in the learning and acquisition of mathematics knowledge and skills in multilingual classrooms. However, this controversy is not new, as it exists in national and international literature on mathematics teaching, as shown earlier.

Human agency

In this study, some students demonstrated that they did not passively wait for assistance from others but took initiative to improve and sustain their excellence in mathematics. They perceived themselves as active agents in their own advancement. The action of taking action with a goal of finding solution to one's problem(s) is referred to as human agency. It involves tapping in intrinsic resources in order to find a solution(s) to problem(s) instead of waiting for someone to assist you. The fact that students had initiated these actions without the help of the lecturers or adults (parents) made them to feel as agents of change. Mandlakayise, a second-year male participant in the Commercial Stream, explained the strategies he devised to improve his performance in mathematics as follows:

I don't wait for the lecturer to solve all my problems so I spend a lot of time practising on my own using the IEB [Independent Education Board] and Cambridge University websites to locate question papers and YouTube to learn to solve maths problems that I don't understand in class.

Bongani, one of the three recently-graduated participants from the Commercial Stream, explained how undertaking independent research had helped him to boost excellence in mathematics,

I always initiated a small research about each and every topic before I attended mathematics lectures. Then I would have enough questions that a lecture needs to clear up before the end of the lesson [sic].

In order to gain a better understanding of the concepts they had learnt in class, students mentioned that they initiated study groups on their own. Winsor (2007, 2008) mentions that after using group work among a diverse group of L2 mathematics students, he noticed that 'student communication became more mathematical' (p. 375). Ncedo, a second-year male participant from the Science Stream, explained:

Although the university offers tutoring, we decided to form our study group of 3 since from first year. Everybody 'pitch in'. This helps us to talk about mathematics in our mother tongue and help us to master mathematics concepts that the lecture could not explain in our vernacular [sic].

Study groups are appropriate and comfortable environments for students to interact and communicate freely with one another about mathematics. Brenner (1994) talks about communication about mathematics, which gives students an opportunity to describe the processes they used to solve a problem and their thoughts about those processes (metacognition). Communicating about mathematics can help students to move gradually towards communicating in mathematics, which refers to using formal mathematical language and symbols (Brenner, 1994).

6. CONCLUSION

Existing literature has shown that there are factors that determine the performance of learners in mathematics in South African schools and elsewhere. These factors include language, as well as school

and home socio-economic factors. This study investigated the effect of language on African student teachers' excellence in mathematics taught through the medium of English L2, as well as factors that contribute to their excellence in this subject. Data showed that language is a controversial issue, with some participants believing that having linguistic capital facilitated their understanding and excellence in mathematics while others perceived no relationship between these variables. Results further revealed that some participants attributed their excellence in mathematics to the within-individual element of human agency. Participants' statements demonstrated the power of within-individual elements that can lead to success regardless of whether or not the individual learner/student has a predisposition to the cultural-linguistic capital of English. The latter findings have far-reaching implications for mathematics teachers, teacher-education lecturers and policy-makers. They suggest that while efforts are made to improve student teachers' performance in mathematics, ways should be found on how to tap in the intrinsic characteristics in order to promote their excellence in mathematics and other subjects. In addition, ways should be found on how to strengthen the resilience of student teachers studying mathematics using human agency and other within-individual elements (e.g. attitudes, motivation). The results of this study provide a fresh, positive and different perspective on research in mathematics, as they demonstrate that L2 students have capacity to excel in this subject and to rise above the circumstances over which they have no control (e.g. home and test language; and school and home socio-economic status). Studies that use multiple lenses in investigating African students' excellence in mathematics should be conducted to improve policy and practice.

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ADDENDUM

Pseudonym	Gender	Study level	Average %
Simba	Male	2nd	98
Ntsika	Male	3rd	96
Dali	Male	Graduate	87
Mandlakayise	Male	2nd	76
Bongani	Male	Graduate	81
Zukiswa	Female	3rd	92
Ncedo	Male	2nd	83

Ngxiki	Male	2nd	78
Mbonwa	Male	3rd	77
Jabu	Female	4th	89
Nobathembu	Female	4th	76
Xolani	Male	3rd	88
Vuyo	Female	3rd	84
Zakhele	Male	Graduate	78