EXAMINING TEACHERS' PERCEPTIONS ABOUT IMPROVING THE TEACHING AND LEARNING OF MATHEMATICS AND STATISTICS

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ABSTRACT

The purpose of this paper is to examine South African teachers' suggestions for improving the teaching and learning of mathematics and statistics, as well as exploring relationships between certain demographic factors and the number and types of strategies suggested by teachers. The study was conducted with 75 South African mathematics teachers. We asked them to respond to closed- and open-ended questions regarding their strategies and plans about how they intend to improve the teaching and learning of mathematics and statistics. The findings revealed that teachers were most concerned with improving the motivation and interest of their learners. Furthermore, there were relationships between the number and types of strategies suggested and certain factors such as attendance at workshops, and use of the curriculum.

Keywords: *Statistics education research; Mathematics teachers; Strategies; Age; Gender; Level of qualification*

1. INTRODUCTION

The Trends in International Mathematics and Science Study (TIMSS) is an international study in which Grade 5 and Grade 9 South African learners participate (for most countries, Grade 8 learners write the test, but in South Africa, it was Grade 9 learners who wrote the test). In 2015, learners from this country were ranked second to last out of a total of 45 countries that partook in the study, both for the Grade 5 and Grade 9 mathematics groups. The report for the Grade 9 study, led Reddy and colleagues (2016) to argue that education and learning are shaped by home, school and community environments with all of these exerting influences of different strengths and different directions. Some learner factors that seemed to influence the TIMSS scores obtained were confidence in mathematics, gender, experience of bullying, frequency of absence from school, education levels of parents and home resources. School factors such as school location, school safety, and amount of importance placed on achievement were also identified as factors of influence on the TIMSS results. Other studies pointed out that low achievement in rural schools might be a result of limited school resources such as school furniture, telephones, photocopiers, learner resource material, electricity, water ablution facilities and audiovisual equipment (Christie, Sullivan, Duku, & Gallie, 2010; Gardiner, 2008; Sao, 2008).

Nationally, the results obtained in the national mathematics examinations written in Grade 12 each year are also very low. The percentage of learners who obtained above 50% in the 2016 national examinations was just 21% rising from 20% in 2015 (Department of Basic Education (DoBE), 2017). The South African government has identified some goals regarding improvement in education:

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> By 2030, South Africans should have access to education and training of the highest quality, leading to significantly improved learning outcomes. The performance of South African learners in international standardised tests should be comparable to the performance of learners from countries at a similar level of development and with similar levels of access. (National Planning Commission, 2013, p. 296)

Some countries with similar levels of development as South Africa are Angola, Turkey, Mexico, and Zimbabwe.

Major concerns of the DoBE of South Africa, are that teachers need support in developing their professionalism and in keeping up activities to improve their teaching skills. In addition, the education department would like to ensure that teachers teach the stipulated content at the required cognitive levels (DoBE, 2017). The Department of Education in KwaZulu-Natal (KZN DoE, 2016) identified that inadequate professional development activities of teaching staff are a major concern and included targets to train over 40,000 teachers in the teaching of mathematics in 2016. The DoBE (2011a) is also concerned that teachers should improve their level of expertise, develop effective teaching skills, and improve their subject knowledge in order to achieve effective learning. Various strategies have been put forward to improve learners' understanding, such as improving teachers' content knowledge, levels of formal qualifications, pedagogic knowledge, and improving the functionality of schools, as well as curriculum coverage (Bansilal, Mkhwanazi, & Brijlall, 2014; Van der Berg, Taylor, Gustafsson, Spaull, & Armstrong, 2011).

Statistics is seen as a small part of school mathematics and has not received much attention about how it could be improved. Statistics education is in its infancy in South Africa. The new curriculum for Grades 10 to 12 with its increase in emphasis on statistics was only implemented in 2006 and culminated in the final grade 12 examination in 2008 (Edwards, 2010). There is much work that needs to be done by mathematics teachers to teach the broadened statistics curriculum. Focused attention on the teaching of statistics may help learners develop the statistical literacy skills they require when they finish school. The development of statistical literacy, at school level, will help orient learners to participate in a data-driven society (Gal, 2002; North, Gal, & Zewotir, 2014).

However, not much is known about the opinions and perspectives of South African mathematics teachers about how they could improve the teaching and learning of mathematics and statistics. This study makes a contribution by looking at what can be done to improve the teaching of mathematics and statistics based on teachers' ideas. We explore what South African mathematics teachers think, need or suggest about how the teaching and learning of mathematics and statistics could be improved.

2. LITERATURE

Educational outcomes in South Africa are still very low and many schools are struggling because of the legacy of apartheid policies that devastated the education system. With the introduction of democracy in South Africa, the Education Department attempted to address discrepancies in teacher training inherited from apartheid policies. Adler (1997) noted that white mathematics teachers were most likely to have a university degree with a minimum of one year of tertiary mathematics, whereas black teachers were "likely to have a three year college teaching diploma, with often extremely little post-secondary mathematics" (Adler, 1997, p. 93). In fact, many colleges of education were viewed as producing teachers of poor quality and during the 1990s many teacher training colleges were shut down while many were incorporated into higher education institutions (universities) in 2001 (Bansilal, 2012; Council on Higher Education, 2010; Rogan, 2007). Teachers who graduated from teacher training colleges had a three-year college qualification and were labelled under-qualified by the Education Department (Bansilal, 2012). Although considerable progress has been made in upgrading teachers in South Africa, there are still many under-qualified teachers in the country. A recent parliamentary reply from the Education Minister (Phakathi, 2017) revealed that in 2016 about 60% of all unqualified and under-qualified South African teachers were in KwaZulu-Natal with a large number of these teaching in the very rural areas.

There are other factors besides just the quality of teachers and teaching that influence the performance of learners particularly in mathematics. Improving learner achievement is not a simple endeavour because of the multidimensionality of the various factors that affect learner achievement in mathematics. In the TIMSS study report, Reddy et al. (2016) investigated the role of the socio-economic

status of learners and showed that the average score achieved by the poorest learners (those who attend the no-fee public schools) was 341. In contrast the more affluent learners (who attend the public fee paying schools) achieved 423 points on average, a difference of 82 points. Note that on the TIMSS achievement scale, a score of 500 corresponds to the mean of the overall achievement distribution (Reddy et al., 2016). The study also revealed that learners whose primary language was the same as the language of the test, achieved on average 60 points higher than those for whom the language of the test was a secondary language.

The accessibility to reading material seemed to influence chances of success as learners who had more than 25 books at home achieved 47 points on average higher than those who had a smaller number of books. The TIMSS study also identified the importance of having a positive attitude towards mathematics. A positive attitude towards mathematics reflects a positive emotional disposition in relation to the subject and, in a similar way, a negative attitude towards mathematics relates to a negative emotional disposition. These emotional dispositions have an impact on an individual's behaviour, as one is likely to achieve better in a subject that one enjoys, has confidence in or finds useful. The results in the South African part of the TIMSS study illustrated that a positive attitude and achievement were related, as those learners who reported that they were confident about mathematics scored on average 89 points higher than those who were not confident (Reddy et al., 2016).

Colgan (2014) argued that teachers could use resources and strategies that increase students' enthusiasm, excitement and concentration to improve their achievement. Applying multiple non-traditional activities and attention-grabbing resources could stimulate interest about mathematics and contribute to understanding the relevance of mathematics in everyday life (Colgan, 2014). On a similar note scholars agreed that if learners have a positive attitude towards mathematics and engage with mathematics, they are more motivated to learn, perceive new ideas and become motivated to solve various challenging tasks (Beswick, 2014; Beswick, Watson, & Brown, 2006; Mata, Monteiro, & Peixoto, 2012). Colgan (2014) called on teachers to change learners' feelings about learning mathematics by shifting the focus from teaching facts and skills to building positive relationships between students and mathematics.

Other scholars like Ebersöhn and Eloff (2004) and Felder and Brent (1999) suggested that teachers should incorporate games in teaching because the use of games in learning mathematics could assist learners to learn new concepts and develop their problem solving practices. Some other studies have shown that integration of technology in teaching mathematics (Moore, 2012) and statistics (Baharun, 2012; Lesser & Groth, 2008) might improve students' understanding. When teachers used technology, especially the internet, in teaching and learning, they gained new insights into the different strategies that they could use in the classroom. Purcell, Heaps, Buchanan, and Friedrich (2013) described the importance of the internet and digital tools in teachers' work of teaching. They stated that "the greatest impact of the internet and other digital tools on their role as teachers has been access to more content and material for use in the classroom and a greater ability to keep up with developments in their field" (p. 51).

Chance, Ben-Zvi, Garfield, and Medina (2007) highlighted the importance of using technology in teaching statistics. They stated that if technology is used effectively in teaching and learning statistics, it has the potential to enhance student achievement and teacher professional development. A recommendation for teachers is that they should focus carefully on data exploration in order to assist students in discovering and constructing meanings for the big ideas of statistics (Chance et al., 2007). Through explorations, learners discover the patterns in the data, and by giving them opportunities to analyse and interpret the data, they are able to make statistical decisions. These techniques are well-known to increase learners' statistical thinking and reasoning. Investigations can also be designed around various types of statistical data such as surveys, observational studies and experiments (Huynh & Baglin, 2017).

Garfield (1995) suggested that statistics teaching and learning could be enhanced by the use of a variety of assessments and skills and the use of software and computer simulation. In their review, Tishkovskaya and Lancaster (2012) found that students in some studies expressed negative attitudes towards statistics because they possessed limited prior mathematical and statistical knowledge. These authors also suggested that, in teaching statistics, teachers should use innovative approaches and a variety of assessment strategies involving statistical reasoning.

The construct of statistical knowledge for teaching (SKT) which is used to describe teachers knowledge and skills in the teaching of statistics, has received much attention in recent studies (Burgess, 2008, 2009). Authors such as Pfannkuch (2008) have focused on dimensions of SKT highlighting that it is necessary for teachers to have knowledge about statistical literacy, thinking and reasoning to improve statistics teaching and learning. In South Africa, statistics has traditionally been taught by using lecturing methods covering the mechanics of statistical methods and the theory of probability and mathematical statistics where students' contribution is restricted (Steffens & Fletcher, 1999). Along the same lines, Wessels (2008) reported that South African teachers did not have sufficient statistical content and pedagogical content knowledge to teach statistics because the teachers had had no effective training in statistics. Scholars suggest that building the capacity of teachers, as mediators of the curriculum, may be the ultimate answer (Moloi, 2005). Professional courses such as the maths4stats course have aimed to develop teachers' skills in teaching statistics. The maths4stats project, was developed in 2007 by Statistics South Africa (StatsSa), which is the National Statistics Office. The aim of this project was to improve statistical teaching in South Africa schools around the country (North & Scheiber, 2008; North & Zewotir, 2006).

The literature review shows that there are many studies with authors making recommendations about how teachers could improve teaching and learning of mathematics and statistics. However, there is scant evidence in the literature of studies on teachers' perceptions regarding improving mathematics and statistics teaching and learning in South Africa, and in KwaZulu-Natal especially. Moreover, as far as we could ascertain from the literature there has been no study on the teachers' voice in terms of their plans and strategies that could be used to improve teaching and learning. Because teachers are at the interface between educational policy and the learners for whom the policy is intended, teachers' suggestions about how mathematics and statistics could be improved must be considered in any education development initiative. The teachers' suggestions articulated in our study may prove helpful to teachers, teacher professional development agencies and policy-makers in terms of improving the quality of teaching and learning. Accordingly the study was aimed at responding to the following research questions:

- What are the suggestions made by mathematics teachers with respect to improving the teaching and learning of mathematics and statistics concepts?
- How do factors related to age, gender, teaching experience, knowledge of curriculum and levels of study influence the strategies mentioned?

3. METHODOLOGY

The sample comprised 75 mathematics teachers who were attending a statistical education workshop in 2015 at the University of KwaZulu-Natal (North & Scheiber, 2008; North, Scheiber, & Ottaviani, 2010), which aimed to improve the statistical knowledge of teachers and to create awareness in mathematics and statistics of teachers and learners (North et al., 2010). The Department of Education purposively selected the teachers from schools located in disadvantaged areas or showing the greatest need for support and improvement. The teachers involved in the study taught mathematics in Grades 4 to 12.

Questionnaires consisting of open-ended and closed questions were administered to the 75 teachers, who volunteered to participate in the study, towards the end of the workshop. The participants were encouraged to write down their strategies and plans regarding how they would go about improving the teaching and learning of mathematics in general and more specifically for statistics by considering topics they chose. The questionnaire used in this study was adapted from the instrument developed by Beswick, Callingham, and Watson (2012). The items regarding teachers' strategies for improving teaching and learning form the focus of this study. The questions requesting teachers to state their strategies for improving teaching and learning, were represented as follows:

> How would you go about improving the understanding of Mathematics and Statistics amongst learners in grade 4 and up? Please state the main goals, plans and strategies that you would use and why (For example: I would improve students' interest in mathematics, because it makes them very nervous about learning it).
>
> 1a) To improve the teaching and learning of Mathematics, I would: …
>
> 1b) I would do this because: …

2a) To improve the teaching and learning of Statistics, I would: …

2b) I would do this because: …

These items formed part of the instrument used by Beswick et al. (2012) in their research about exploring the nature and development of middle school mathematics teachers' knowledge where they focused only on the quantitative results. In this study, we used a mixed methods approach that combines both qualitative and quantitative methods of analysis. Quantitative methods became relevant when we coded teachers' demographic factors and when we counted the number of approaches reported by teachers to improve mathematics and statistics learning. These methods are discussed in Section 4.3. Qualitative methods were used to describe the strategies suggested by teachers. Teachers' responses were coded qualitatively in order to examine the types of strategies that teachers suggested. Therefore, the teachers' responses to the item regarding their suggestions about improving mathematics and statistics teaching and learning were analysed for emerging themes. We used a general inductive analysis by independently coding all teachers' responses about improving mathematics and statistics into broad categories. The codes were first assigned independently by the first and second co-authors. The three authors then reviewed the coding and together reached consensus where differences occurred. This process was carried out with the intention of improving the reliability and validity of the coding which are essential aspects of trustworthiness in qualitative analysis.

4. RESULTS AND DISCUSSION

First, the characteristics of the participants are presented according to the number of teaching strategies they suggested. Second, the results are discussed in relation to the two research questions.

4.1. DEMOGRAPHIC FACTORS AND NUMBER OF TEACHING STRATEGIES SUGGESTED

Table 1 provides information regarding the 75 participants, grouped by gender, age group, experience and the level of education, grouped according to the strategies they suggested. The characteristics of the participants have been grouped according to the number of the strategies they suggested in mathematics and in statistics. The information presented in Table 1, alerts us to some factors that may be associated with teachers' tendency to use multiple strategies, and these were tested (see Section 4.3). For instance, we note that 56.8% of female teachers suggested multiple strategies for improving mathematics compared to 31.6% of male teachers. Also 52.3% of young teachers, suggested multiple strategies for improving mathematics compared to 32.3% of older teachers; 55.6% of those who integrate curriculum suggested multiple strategies for improving mathematics and statistics

Table 1. Number (and percentage) of strategies by teachers' demographic factors

Factors	Codes	Mathematics		Statistics		Total
		Single strategy	Multiple strategies	Single strategy	Multiple strategies	
Gender	F	16(43.2)	21(56.8)	19(51.4)	18(48.6)	37
	M	26(68.4)	12(31.6)	19(50.0)	19(50.0)	38
Age (in years old)	≤ 40	21(47.7)	23(52.3)	22(50.0)	22(50.0)	44
	> 40	21(67.7)	10(32.3)	16(51.6)	15(48.4)	31
Teaching experience (in years)	≤ 10	24(53.3)	21(46.7)	23(51.1)	22(48.9)	45
	> 10	18(60.0)	12(40.0)	15(50.0)	15(50.0)	30
National Curriculum Statement Grade R–12	Not used	21 (70.0)	9 (30.0)	17(56.7)	13(43.3)	30
	Used	20 (44.4)	25 (55.6)	20(44.4)	25(55.6)	45
Highest level of education	Undergrad or lower	22(62.9)	13(37.1)	25(71.4)	10(28.6)	35
	Postgrad or above	20(50.0)	20(50.0)	13(32.5)	27(67.5)	40
Previously attended mathematics/statistics workshops	No	22(73.3)	8(26.7)	22(73.3)	8(26.7)	30
	Yes	20(44.4)	25(55.6)	16(35.6)	29(64.4)	45

compared to 30.0 % of those who did not use it; 67.5 % of those who studied at postgraduate level or more, suggested multiple strategies for improving statistics compared to 28.6% of those who only studied at undergraduate level; and 64.4% of those who attended previous mathematics workshops suggested multiple strategies for improving statistics compared to 26.7 % who did not attend them.

4.2. WHAT ARE THE SUGGESTIONS MADE BY MATHEMATICS TEACHERS WITH RESPECT TO IMPROVING THE TEACHING AND LEARNING OF MATHEMATICS AND STATISTICS CONCEPTS?

There were six main categories emanating from the data with respect to the teaching of mathematics and statistics as shown in Table 2. These include increasing motivation and interest of learners, teachers' explanations, linking teaching to real life, using practical activities and concrete examples, attending professional workshops, and using investigations and projects. The descriptions are presented in more detail thereafter. Note that the teachers' responses are quoted verbatim without any editing.

Table 2. Teachers' strategies for improving mathematics and statistics

Category-Description	Frequency for mathematics (%)	Frequency for statistics (%)
Increase motivation and interest of learners (IM)	45(33.1)	28 (23.7)
Focus on improving teacher explanations, advance preparation, going back to basics and providing more opportunities for practice (TEB)	34(25.0)	28 (23.7)
Links to real life settings (RL)	15(11.0)	20 (17.0)
Use of practical activities, and concrete examples (UPE)	19(14.0)	15 (12.7)
Attend teacher professional development meetings and workshops (PD)	18 (13.2)	12(10.2)
Use of investigations and data handling projects (INV)	5 (3.7)	15 (12.7)
Total	136 (100.0)	118 (100.0)

Increasing motivation and interest of learners (IM) This category elicited the highest number of suggestions. There were 45 (33.1%) strategies in this category related to improving the motivation and interest in mathematics and 28 (23.7%) similar suggestions related to the teaching of statistics. In this category we considered suggestions that related to increasing learners' motivation by emphasising the fun element of mathematics/statistics, showing the importance of the subject, showing how easy it was or by using learner-directed activities to build up their interest. Teachers felt that increasing learners' motivation was crucial because many learners are uninterested, see mathematics or statistics as boring and do not see the value of the subject.

The comments in this category revealed the extent of teachers' concern about learners' attitudes to mathematics in general. Of the 45 suggestions related to mathematics, 24 were focused on showing that mathematics is fun and providing ways that could be used to improve the interest of the learners. With respect to statistics, there were 10 comments focused on emphasising the fun or enjoyment associated with the subject. An example of such a comment is "Make my topic as fun as a joke … and make them laugh to help them understand" because the teacher felt that learners "were afraid of mathematics." Fifteen comments (9 for mathematics and 6 for statistics) were directly related to efforts that could decrease mathematics anxiety, for example, "Ensure that I teach them with enthusiasm to eradicate mathematics phobia."

The phenomenon of mathematics anxiety has long been recognised as a negative influence on learners' achievement. Schukajlow (2015) found that many learners are afraid of mathematics, and they often perceive mathematics as difficult. Some studies, which have been conducted on the issue of learners' attitudes towards mathematics (Buckley, 2013; Hembree, 1990; Schukajlow, 2015), argue that mathematics anxiety can contribute to poor performance in mathematics activities. The teachers' concern also came to the fore in our study where teachers' comments suggested that they were concerned because their learners did not see mathematics or statistics as interesting and important. They emphasised that they would like to provide learners with opportunities to improve their learners' love of mathematics and reduce their fear about the subject. In the TIMSS in 2015, learners were asked to

respond to questions about their self-concept regarding their ability to learn mathematics. The TIMSS results revealed a positive relationship between learners' belief in their ability and their performance, with the scores of confident learners being 89 points on average higher than those of non-confident learners (Reddy et al., 2016).

One of the ways that teachers suggested that learners' interest could be ignited was through the use of games because of the fun element and making learning enjoyable. There where nine and four teachers who made this suggestion for mathematics and statistics respectively. Teachers suggested that through games, learners may become inspired and learn to love mathematics, which is supported by researchers who argue that incorporating games in teaching and learning mathematics is important because insight and the development of new perceptions are often facilitated through games (Ebersöhn & Eloff, 2004; Felder & Brent, 1999). Games can assist learners who feel that mathematics is difficult to become more enthusiastic (Gaol, Hutagalung, Bagautdinova, & Safiullin, 2016).

A strong thread running through many of the responses was the need to show why mathematics or statistics was important and why learners should learn the subject. There were six similar comments for mathematics and for statistics arguing that learners needed to be convinced about why we study mathematics/ statistics and how it was related to other subjects. They indicated that improving learners' interest in the subject could help the students to appreciate the importance of mathematics/statistics, increase their enthusiasm and support them in creating a positive attitude towards the subject, because mathematics is the key to everything they do in life. A suggestion by six (one for mathematics and five for statistics) was that learners' motivation could be improved by using self-directed activities that allowed learners to take responsibility for their own learning of mathematics and statistics. An example is "I would allow learners to create their own scenarios."

***Clearer explanations and more practice (TEB*)** In this category we considered suggestions related to improving teacher explanations, preparing lessons in advance, going back to basics and providing more opportunities for practice. This category was the second highest with 34 (25.0%) and 28 (23.7%) suggestions related to the teaching of mathematics and statistics respectively. Concerns about learners' struggles with basic concepts, which form a cornerstone of more advanced concepts, were clearly articulated by many teachers. Some teachers felt that by providing clearer explanations, learners may understand the content better. One such comment was "Try and make it understandable, by explaining at a lower level /simplified level," which shows the importance placed by the teacher on targeting the explanations at the level at which the learner is. Some comments emphasised the need for learners to understand the fundamental or basic concepts upon which other concepts are built upon: "Make sure they understand the basic."

Other teachers suggested spending more time teaching learners in order to improve their knowledge and by setting extra work. One teacher explained that s/he was prepared to start school at 6.30 a.m., effectively adding 1½ hours to the day: "Take more time with them and using extra time and holidays when periods start at 8:00 a.m. I will start at half past 6 am it was explained that learners need to be given enough time to understand mathematics because these are domains that require high levels of reasoning." The strategy evoked by the some teachers in regard to increasing class time must be treated with caution. An increase in instructional time can be risky because it may reduce the cognitive disposition of the pupils because of the fatigue that might result from the additional school hours. Another suggestion emphasised the need to focus on the big or key ideas of a concept when teaching a concept: "First the key concepts and key word and explain that key word and give the formulas that are needed to be used. It is imperative to know key concepts so that you can understand the related content." Some teachers conveyed their belief in the power of practice: "Tell the learners that in order for them to understand mathematics they will need to practice every day." The teachers' suggestions reflect some concerns raised in recent research that learners spend too little time engaging with mathematics, which is a reason for the low outcomes in the subject (DoBE, 2017; Reeves & Muller, 2005; Taylor, 2011).

Making links to real life (RL) Under this category we considered broad suggestions about using real life examples in the classroom to improve the participation and engagement of learners. There were 15 (11.0%) and 20 (17.0%) strategies provided in mathematics and statistics respectively. These comments indicated that teachers saw the need for learners to see the real-life applications of mathematics and statistics. They believed that linking mathematics to real life enabled learners to

participate in other fields and not only in the classroom. They also felt that the application of content to real-life situations supported learners in becoming mathematically literate, and helped them to deal with daily life situations. In their opinion, teaching statistics by linking it to real life would enable their learners to use the knowledge gained in the classroom in their own life experience. They needed to understand that statistics is also applied in real life. Teachers also remarked that using real life examples helped learners apply statistics in many services such as economics, business, money market and their financial planning.

Many of the suggestions made in this category were broad generalisations such as "relate abstract concepts in the class to real world" and "Use real-life situations," without giving more specific links about how this could be done. In their study about exploring teaching strategies of students registered in a master's degree program, Smith and Martinez-Moyano (2012) noted that the most common suggestion offered was that the use of real-life examples was an absolute necessity. In South Africa there is much interest in trying to address this problem by linking curricula to real life settings. In fact, one subject (Mathematical Literacy) was made compulsory for all Grade 10-12 learners who opted not to study pure mathematics and was designed so that it only dealt with various applications of mathematics in everyday life (DoBE, 2011b). This may explain why our South African teachers find it compelling to stress the importance of making real life links in the mathematics or statistics classroom.

Using practical or concrete examples (UPE) Closely linked to the category of real life examples but different in purpose, is that of using concrete examples or physical models to help make the abstract concepts more accessible. A practical approach describes a learning environment where learners operate real objects that enable them to become familiar with the figures and their properties. There were 19 (14.0%) and 15 (12.7%) suggestions made in this regard for mathematics and statistics respectively. Some responses that were given by the teachers included "Teach using more practical activities to familiarise them and to improve their interest" and "I would also use concrete ideas like bringing die and some teaching aids." By using practical examples, Adetunde (2009) argued that learners understood better if they could see and move things instead of just listening. These teachers clearly saw it as a way for motivating their learners to focus and gain an interest in the field.

Professional development (PD) The teachers also reflected about improvements they could target with respect to their own personal and professional development and growth. This category of professional development comprised suggestions that teachers would attend workshops to improve their qualifications or to develop their content knowledge. We also included suggestions about meeting with other teachers to reflect on and improve their own teaching. There were 18 (13.2%) and 12 (10.2%) such suggestions related to mathematics and statistics respectively.

Some teachers suggested that attending professional development workshops would improve their teaching skills, for example "Attend and conduct workshops on statistics (data handling)." One teacher specifically mentioned the need to learn more up-to-date methods of teaching: "Use the modern method which I receive here when I am attending workshop at statistics." This is noteworthy considering that research reports that much of the teaching of mathematics is taught by traditional methods in South African schools and that teachers teach it using the way they had been taught (North & Zewotir, 2006). Teachers felt that by attending workshops they enhanced their interest and became more aware of the importance of teaching and learning mathematics.

Teachers noted that they needed to grow in their field and gain an understanding of more pedagogical strategies that they could use in class to assist their learners. Many teachers suggested that they would attend statistics workshops in order to improve their knowledge in statistics so that they could help learners understand the calculations using statistics in daily life. Some teachers mentioned that statistics workshops helped them to learn much more about statistics (data handling). They also believed that attending workshops enabled them to develop their own levels of statistical literacy, improve their knowledge and could lead to formal qualifications. For example, "Need more courses or workshops and I need the diploma in mathematics."

Using investigations and projects (INV) We also considered suggestions about possible investigations or projects that could be carried out. Investigations are used to "discover rules or concepts and may involve inductive reasoning, identifying or testing patterns or relationships, drawing

conclusions, and establishing general trends" (DoBE, 2011b, p. 295). Projects are also used to help learners understand mathematical rules and their application in real life. There were five suggestions made for mathematics and three times as many, 15 (12.7%), for statistics. This difference is likely because the teachers were attending a statistics education workshop meant to improve their knowledge of statistics. Hence, the exposure they received to possible statistics investigations may have alerted them to the value of conducting investigations. An example of such a suggestion was "I would make use of investigations that involve learners gathering themselves, then analysing and interpreting." DoBE (2011b) also recommended that mathematics teachers should involve investigations as a way of assessing students' knowledge, as investigations helped students to develop their level of creativity and the ability to think critically.

4.3. HOW DO FACTORS RELATED TO AGE, GENDER, KNOWLEDGE OF CURRICULUM AND LEVELS OF STUDY INFLUENCE THE STRATEGIES MENTIONED?

In analysing the various strategies, we found that some teachers presented many strategies. For example, one teacher wrote "Motivate learners to see mathematics as for other subject to change attitude. Plan activities that would excite learners in class. Involve learners by making them see how the difference between population to sample, allow learners to collect, analyse and present data." However, there were other teachers who seemed to be content with providing just one strategy: "Discourage use of calculators." The difference seems to be related to the teacher's willingness to reflect about the various issues that impact on the teaching and learning situation. Teachers who presented multiple suggestions were assumed to have spent more time engaging in the issue at hand than others who presented only one suggestion. We then investigated whether certain demographic factors appear to be associated with the teachers' tendencies to discuss multiple strategies and we also looked at the role of demographic factors in suggesting specific strategies.

Details of the binary logistic regression Binary logistic regression was used to model teachers' suggestions and teachers' demographic factors, given that the response variable is dichotomous (Harrell, 2015; Hellevik, 2009). Logistic regression is used to determine the relationship between the dependent variable response or outcome variable and a set of independent or predictor or explanatory variables. Logistic regression assumes that the response variable is categorical. When the response variable has two outcomes (e.g., inappropriate answer/ appropriate answer; failed/ passed), the model is termed binary logistic regression. The independent variables considered in this study include gender, age, teaching experience, using the curriculum, as well as level of education of the teachers. Table 4 reflects the response variables used in the models. The response variables were coded using dummy codes, such that 0 indicates a single strategy and 1 indicates multiple strategies expressed by teachers in terms of improving the teaching and learning of mathematics and statistics; this made it binary. Therefore, the reference category was the highest code group as the comparison group. The analysis

Table 4. Description of the response variables

Category	Response variables	Codes	Total (%)
Improving mathematics	Single strategy	0	42 (56.0%)
	Multiple	1	33 (44.0%)
Improving statistics	Single strategy	0	38 (50.7%)
	Multiple	1	37 (49.3%)

was made using IBM SPSS version 23 (George & Mallery, 2016). Table 4 displays the number of different strategies suggested by teachers in relation to improving teaching and learning of mathematics and statistics.

Model Fit In order to assure the goodness of fit for the model of improving mathematics and statistics teaching and learning, the omnibus test statistic was used to assess whether there was a linear relationship between the probability of improving mathematics and statistics using a single strategy or

multiple strategies and the demographic factors. An omnibus test statistic with *p*-value less than 0.05 implied that the logistic regression could be used to model the data. Model selection was done using the standard method (Enter) (Muchabaiwa, 2013). This means that all variables in a block are entered in a single step. Table 5 indicates that chi-square values of all three tests are the same and their probabilities are less than 0.05 for the two models. This indicates that at least one of coefficients of the predictors is not equal to zero.

Table 5. Omnibus tests of model coefficients

Test		Improving mathematics (model 1)			Improving statistics (model 2)		
		Chi-square	DF[a]	*p*-value	Chi-square	DF[a]	*p*-value
Step 1	Step	27.500	5	0.000	25.124	5	0.000
	Block	27.500	5	0.000	25.124	5	0.000
	Model	27.500	5	0.000	25.124	5	0.000

[a]DF = degrees of freedom, or the number of factors included in the model

Model summary statistics were checked in Table 6. We note that Nagelkerke's R^2 values are 0.411 (for mathematics) and 0.380 (for statistics), which indicates that the models are good.

Table 6. Model summary

Step 1	Improving mathematics			Improving statistics		
	-2 LL[a]	CS R^{2b}	N R^{2c}	-2 LL[a]	CS R^{2b}	N R^{2c}
	75.390	0.307	0.411	78.835	0.285	0.380

[a]-2 LL = –2 × log loglikelihood; [b]CS R^2 = Cox & Snell R-squared, [c]N R^2 = Nagelkerke R-squared

Furthermore, Hosmer-Lemeshow (H-L) goodness-of-fit statistics (Hosmer & Lemeshow, 2000), were also used to assess the fit of the models. This test compares the predicted values against the actual values of the dependent variable. The method is similar to the chi-square goodness of fit. A very small chi-square of H-L test statistic is desirable and a *p*-value greater than 0.05 indicates that the model is acceptable (Hosmer & Lemeshow, 2000). The findings reflected in Table 7 indicate that the chi-square values of H-L test and non-significant *p*-values (the values are greater than 0.05), were improved after removing insignificant factors. Therefore, this indicates the goodness of fit of the models.

Table 7. Hosmer and Lemeshow test

Test	Improving mathematics (model 1)			Improving statistics (model 2)		
	Chi-square	DF[a]	*p*-value	Chi-square	DF[a]	*p*-value
Step 1	6.967	8	0.540	3.077	7	0.878

[a]DF = number of groups – 2

Results from the logistic regression Tables 8 and 9 present the parameter estimates of demographic factors fitted with teachers' strategies, using the logistic regression model. Note that we have reported only on those factors that were found to be statistically significant.

Table 8. Parameter estimates for teachers' strategies about improving mathematics

Factors	Coefficients ($\hat{\beta}$)	SE	Wald	*p*-value	OR^s
Gender (Male = ref)	1.513	0.591	6.550	0.010	4.540
Maths w/shops attend (Yes = ref)	-1.625	0.651	6.223	0.013	0.197
Use curriculum (Yes = ref)	-1.938	0.640	9.165	0.002	0.144
Age (> 40 = ref)	1.614	0.662	5.954	0.015	5.025
Constant	-0.399	0.664	0.362	0.548	

[a]OR = $\exp(\hat{\beta})$

The findings presented in Table 8 show that, as compared to males, female teachers were 4.5 times more likely to suggest multiple strategies in relation to improving mathematics teaching and learning rather than a single strategy (p-value = 0.010, $\underline{OR}$ = 4.540). It is also noted from Table 8 that teachers aged ≤ 40 years are (around five times) more likely to express multiple strategies for improving mathematics than is the case for teachers aged > 40 years (p-value = 0.015, OR = 5.025). Furthermore, the findings indicated that teachers who said they did not use the curriculum document, were significantly less likely to suggest multiple strategies in improving mathematics and statistics teaching and learning than those who did use the document (Table 8: p-value = 0.002, OR = 0.144 and Table 9: p-value = 0.043, OR = 0.281). This finding supports the importance of teachers engaging with the curriculum documents, further supporting the view that the curriculum documents are a road map for teachers and they should refer to them often (Makas, 2009). As the findings indicated, teachers who used the curriculum documents seem to be aware of more strategies for improving teaching of mathematics and statistics than teachers who did not do so. Table 9 presents the parameter estimates for strategies related specifically to the teaching and learning of statistics.

Table 9 shows that that teachers whose highest level of study was an undergraduate or lower qualification were less likely to express multiple strategies in terms of improving statistics than is the case for teachers whose highest level of study is a postgraduate qualification (p-value = 0.001, OR = 0.129). On its own, this result may seem innocuous but it is helpful to see this within the South African teacher training context as elaborated in the literature review. It is an important finding that a practicing mathematics teacher with a postgraduate qualification in teaching demonstrates a broader understanding of educational issues related to the teaching of mathematics and statistics. The teachers who hold postgraduate qualifications are the ones who either

Table 9. Parameter estimates for teachers' strategies about improving statistics

Factors	Coefficient ($\hat{\beta}$)	SE	Wald	p-value	OR^a
Maths w/shops attend (Yes = ref)	-1.541	0.580	7.068	0.008	0.214
Use curriculum (Yes = ref)	-1.270	0.627	4.099	0.043	0.281
Level of Education (postgrad or above = ref)	-2.051	0.639	10.302	0.001	0.129
Constant	2.166	0.777	7.775	0.005	

[a]OR = $\exp(\hat{\beta})$

completed their initial training at universities or have studied further at university to raise their level of qualification. Tables 8 and 9 further indicate that teachers who said that they have not attended mathematics workshops were less likely to express multiple strategies for improving mathematics and statistics (p-value = 0.013, OR = 0.197 and p-value = 0.008, OR = 0.214). This finding indicates the importance of professional learning in terms of developing teaching and learning. In fact, an analysis of the suggestions made by teachers with respect to the category of professional development, showed that the teachers with a 3-year or lesser qualification uniformly indicated the need for attending workshops to improve their knowledge or qualification, whereas amongst the postgraduate group, no one indicated compliance with the suggestion. This finding is indeed something to be noted, in terms of the South African context, where teachers from teacher training colleges have only a 3-year qualification and find it difficult to upgrade their qualifications (Bansilal, 2012), because it demonstrates that teachers want the opportunity to improve their teaching qualifications.

We further found that young teachers held more positive beliefs towards mathematics and statistics teaching, compared to older teachers. For instance, amongst young teachers compared to older teachers, we found that more of the younger teachers agreed that teachers of mathematics should be fascinated with how learners think and be intrigued (interested) by alternative ideas (55.7% versus 44.3%), and statistical material is best presented in an expository style: demonstrating, explaining and describing concepts and skills (59.4% versus 40.6%), etc. This is supported by the analysis of the specific suggestions according to age, where younger teachers provided 72.2% of suggestions related to improving teacher explanations (TEB) as compared to only 27.8% of strategies provided by the older group. Furthermore, the group of younger teachers provided 61.2% suggestions that were related to using practical examples (UPE) and making links to real life (RL), whereas the group of older teachers provided only 38.8%. Day and Gu (2007) found that there is a variation in teacher effectiveness at every

stage of the teaching career, and we see in this study that younger teachers are more willing to provide various strategies that they think will improve the teaching and learning of mathematics or statistics than older teachers. It may be likely that younger teachers are also more enthusiastic and motivated as older teachers are more likely to experience burnout as shown in the study by (Philipp & Kunter, 2013) where they found that the level of emotional exhaustion increased with age in their sample of 1939 German teachers.

5. CONCLUSION

In this article, we reported on the suggestions made by teachers about how they could improve mathematics and statistics teaching and learning. This study provides insights into South African mathematics teachers' suggestions for improving the teaching and learning of mathematics and statistics.

The findings revealed that teachers' suggestions were mostly concerned about improving motivation, interest and knowledge of their learners in mathematics, concerns which are shared by many mathematics teachers and researchers (Chance et al., 2007; Ebersohn & Eloff, 2004; Reddy et al., 2016). The teachers suggested various ways in which they could improve motivation and emphasised the use of concrete examples and manipulatives when mediating concepts. The use of concrete examples and manipulatives in helping students cope with the abstractness of mathematics concepts has been suggested by researchers such as Tall (2008) who argued that engaging in concepts in a conceptual embodied world can support the development of symbolic thinking. There was also a call for making real-life links to the mathematics and statistics topics. These suggestions may indicate how much teachers struggle to keep their learners motivated and interested in mathematics in a rapidly changing world, a concern which is echoed by different studies conducted in various contexts (Adetunde, 2008; Chance et al., 2007; Gal, 2002; DoBE, 2011b). In the discussion of the results for each theme, links between the teachers' suggestions and research findings were elaborated, illustrating the value of their suggestions. Furthermore, it is important that policy makers and professional development interventions take note of the strategies proposed by the teachers because they are well placed to offer the suggestions for improving the teaching and learning mathematics and statistics.

In addition, we investigated whether there appeared to be certain factors that influence teachers' willingness to mention multiple strategies. Although we looked at the difference between mentioning multiple strategies and a single strategy, it may be that some teachers do believe that multiple strategies should be used in the teaching and learning of mathematics and statistics, but are not aware of a variety of strategies to do so due to a lack of professional development.

The study revealed some interesting associations between the frequency and types of suggestions and the factors of age, gender, education level, attending professional development workshops and familiarity with curriculum documents. It was found that teachers who attended professional development workshops, were more likely to express multiple strategies about improving mathematics and statistics than those who did not. Furthermore, those who used the curriculum regularly were also more likely to express multiple strategies for improving mathematics and statistics than those who did not. In addition, it was found that younger teachers were more likely to present multiple strategies about improving mathematics, suggesting greater enthusiasm for tackling the numerous problems faced by teachers. There was further a difference according to gender with female teachers being more likely to present multiple strategies for mathematics than their male counterparts. The study therefore suggests that certain groups of teachers (grouped according to the factors considered in the study, such as age) who had fewer strategies to suggest may be in greater need of professional development. This finding would be useful for professional development agencies in South Africa to take into consideration when planning interventions.

Furthermore, it was found that higher proportions of certain groups of teachers preferred particular strategies. It is no surprise to note that those who suggested upgrading existing knowledge were teachers who had undergraduate or lower qualifications, and not the ones who had completed postgraduate studies. It was also found that the teachers with an undergraduate or lower qualification strongly suggested attending workshops to improve their knowledge or qualification, showing how important the issue of upgrading is taken by these underqualified teachers in the education.

It is important to acknowledge the limitations of the study. For instance, the participants were not randomly selected. The study was conducted with the teachers who were selected purposively by the Department of Basic Education. Thus, the findings are based on a group of teachers who were attending professional development courses in statistics. Furthermore, of the 136 teachers who participated in the programme, only 75 teachers agreed to participate in the study. In future studies, we hope to have access to larger samples that will allow us to generalize our findings. A further limitation is that we used only a questionnaire to probe teachers' views. Perhaps interviewing small groups of teachers may provide further support for the findings.

Overall, the study indicated that there is a variation in the interests and needs of the teachers, which must be acknowledged by professional development agencies. Teachers have their own personal trajectories of development initiated by their experiences, and their successes, fears, hopes and perceptions are shaped by these experiences. However, they also revealed and emphasised many common concerns, which must be taken into account in future offerings of the programme and should also be noted by education authorities in South Africa.

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