p-ISSN: 2184-044X e-ISSN: 2184-1489 ISBN: 978-989-54815-2-1 © 2020
DOI: 10.36315/2020end019

EXPLORING SOUTH AFRICAN IN-SERVICE TEACHERS' BASELINE KNOWLEDGE OF MATHEMATICS: A CASE OF FURTHER EDUCATION AND TRAINING PHASE

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Abstract

The advent of the fourth industrial revolution provides opportunities for teachers as key agents of educational change to fully embrace digital transformation in its broadest sense with a view to foster pedagogic innovation. In view of this key strategic imperative, this study explored South African in-service teachers' baseline knowledge of mathematics in the Further Education and Training (FET) Phase. In terms of the structure of the Curriculum and Assessment Policy Statement (CAPS), the FET Phase is comprised of Grades 10, 11 and 12. A mathematics professional development intervention involving 30 teachers was implemented during which a diagnostic assessment test was administered as a pre-test and post-test to evaluate teachers' baseline knowledge of FET mathematics. The results of the diagnostic assessment test revealed pervasive knowledge gaps associated with various topics in FET mathematics. In addition, there was no meaningful correlation between teacher professional experience and knowledge of FET mathematics. While the pre-test results painted a gloomy picture about teachers' baseline knowledge of FET mathematics, the post-test results revealed a marginal improvement with the overall performance of the teachers remaining below 65%. The inadequate learner performance in mathematics in South Africa can partly be attributed to pervasive knowledge gaps exhibited by teachers in various topics. There is a critical need for sustainable teacher professional development interventions to strengthen teachers' content knowledge and pedagogical content knowledge in mathematics as a key knowledge domain. Implications for sustainable teacher professional development and meaningful curriculum reform are discussed.

Keywords: *Teacher professional development, curriculum reform, pedagogic innovation.*

1. Introduction

The enhancement of teachers' content knowledge and pedagogical content knowledge remains a key strategic imperative within the broader South African educational context. South Africa faces the imperative to provide a globally competitive curriculum that is responsive to the acceleration of socio-economic development. Meaningful curriculum reforms ought to be underpinned by a coherent implementation of appropriate strategic interventions which cater for the critical needs of both teachers and learners. The cultivation of mathematical skills is central to meaningful enhancement of human capital development. The generation of optimal levels of economic growth requires higher-order mathematical skills. As agents of educational change, teachers are expected to play a pivotal role towards the progressive realization of this noble goal. However, research has demonstrated that while teachers are competent solvers of school mathematics problems, they are often unable to analyse and interpret learners' errors for diagnostic purposes (Ndlovu, Amin & Samuel, 2017). This reality calls for provision of sustainable professional development opportunities aimed at the enhancement of teachers' subject matter knowledge. The Grade 12 Moderators' Report compiled by the South African Department of Basic Education in 2014 calls for a nuanced examination of the enablers or inhibitors of teaching and learning of mathematics at secondary school level in particular.

2. Research design and methodology

A mathematics professional development intervention involving 30 teachers was implemented during which a diagnostic assessment test was administered as a pre-test and post-test to evaluate teachers' baseline knowledge of FET mathematics. This intervention formed an integral part of continuous professional development efforts aimed at holistic enhancement of in-service teachers' content knowledge and pedagogical content knowledge coordinated by the provincial Department of Basic Education in the Limpopo Province of South Africa.

3. Findings

Table 1 below provides the demographic profile of the participants. A considerable number of the participants possessed a College Diploma as a teaching qualification while others possessed Advanced Certificate in Education and University Degree as teaching qualifications.

Table 1. Demographic profile of the participants.

Age		**Teaching Experience**		**Qualifications**	
< 30 years	43%	< 5 years	15	College Diploma	17
30-39 years	14%	5-10 years	5	Advanced Certificate in Education	6
40-49ears	43%	> 10 years	10	University Degree	7

The frequencies indicating participants' confidence rating of various FET mathematics topics are depicted in Table 2 below. The distribution of frequencies demonstrated that the professional confidence of the teachers in various FET mathematics topics was not firmly established.

Table 2. Frequencies indicating participants' confidence rating of various FET mathematics topics.

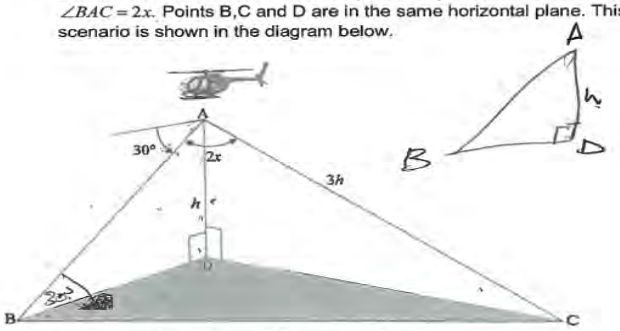
Topic	**Confidence rating**				
	Very confident	**Just confident**	**Slightly confident**	**Not confident**	**Neutral**
Arithmetic sequence and series	9	4	4		13
Geometric sequence and series	9	4			17
Real numbers	9		4		17
Algebraic expressions and equations	9	8			13
Roots, exponents and surds	13				17
Logarithms, remainder and factor theorem	13				17
Triangle geometry	17				13
Volume and area	9	4		4	13
Circle geometry	4	9			17
Similarity of triangles	5	4	4		17
Trigonometric ratios	4	9	4		13
Trigonometric identities	5	4	4		17
Compound angles	4	9			17
2D & 3D problems	9	12	9		
Univariate numerical data	4	9	13	4	
Bivariate data and regression	9	4			17

An extract below captures fundamental difficulties encountered by the participants with regard to the application of trigonometric ratios.

p-ISSN: 2184-044X e-ISSN: 2184-1489 ISBN: 978-989-54815-2-1 © 2020

Figure 1.

1. A pilot is flying in a helicopter. At point A, which is h metres directly above point D on the ground, he notices a strange object at point B. The pilot determines that the angle of depression from A to B is $30°$. He also determines that the control room at point C is $3h$ metres from A and $\angle BAC = 2x$. Points B,C and D are in the same horizontal plane. This scenario is shown in the diagram below.



1.1 Determine the distance BD in terms of h. (2)

$\tan x = \frac{\sin x}{\cos x}$

$= \frac{x}{1}$

$= \frac{h}{3h}$

An extract below depicts difficulties encountered in finding the general solution of trigonometric equations.

Figure 2.

3. Find the general solution: $2\sec^2 x - 11\tan x + 13 = 0$ (5)

$2\left(\frac{1}{\cos x}\right)^2$

$2\left(\frac{1}{\cos x}\right)^2 - 11\frac{\sin x}{\cos x} + 13 = 0$

$2\left(\frac{2}{\cos^2 x}\right) - 11\frac{\sin x}{\cos x} + 13 = 0$

3

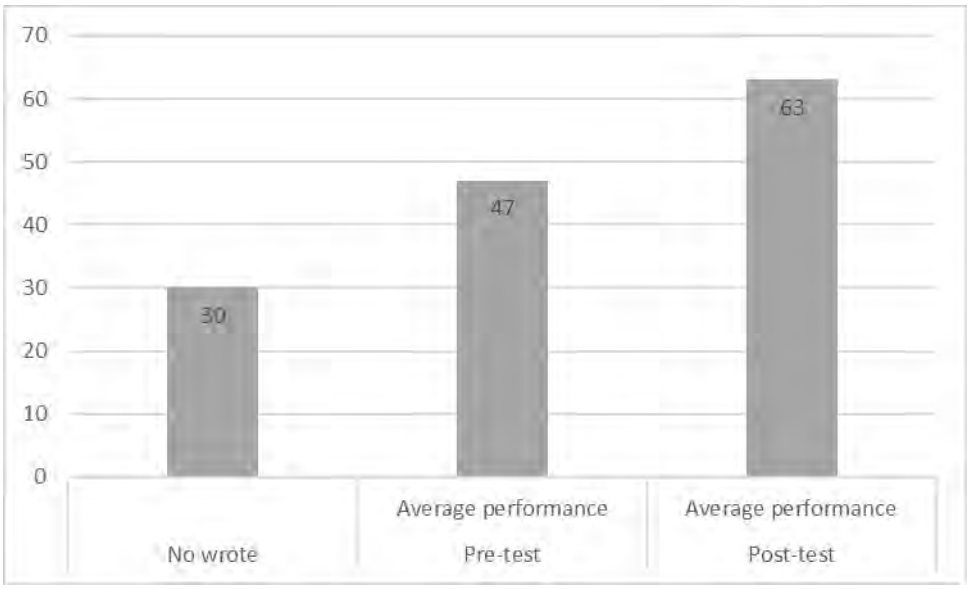
Table 3 below provides participants' perceptions about the professional development intervention. While the participants demonstrated fundamental appreciation of the efficacy of the professional development intervention, they further provided contextually appropriate recommendations on the improvement of the intervention itself.

Table 3. Participants' perceptions about the professional development intervention.

I have achieved my goal as all my expectations were met
The overall delivery of the workshop was excellent
We need a workshop like this in future to address issues like optimization in Mathematics
The workshop developed me in terms of subject content
We need many workshops of this nature
We should be divided into respective groups according to grades during the workshop
The duration of the workshop must be reconsidered
More time is needed to focus on key areas of concern during the workshop

The pre-test and post-test average performances are illustrated in Figure 3 below. While the average performance improved as a result of the professional development intervention implemented, the participants still demonstrated pervasive knowledge gaps which required additional time to address. This observation is consistent with the sentiments expressed by the participants with regard to the recommended prolonged duration of the professional development intervention. This implies that the affordances provided by strategic professional development interventions of this nature ought to be harnessed with a view to enhance the quality of education.

Figure 3. Pre-test and post-test average performances.



4. Discussion

Assessment of in-service teachers' baseline knowledge of mathematics revealed the prevalence of pervasive knowledge gaps associated with various topics in FET mathematics. In addition, there was no meaningful correlation between teacher professional experience and knowledge of FET mathematics. While the pre-test results painted a gloomy picture about teachers' baseline knowledge of FET mathematics, the post-test results revealed a marginal improvement with the overall performance of the teachers remaining below 65%. The inadequate learner performance in mathematics in South Africa can partly be attributed to pervasive knowledge gaps exhibited by teachers in various topics. There is a critical need for sustainable teacher professional development interventions to strengthen teachers' content knowledge and pedagogical content knowledge in mathematics as a key knowledge domain. Several researchers argue that mathematical knowledge for teaching is crucial for successful teaching, realization of learning outcomes and learner attainment (e.g. McAuliffe, 2013; Bansilal, Brijlall & Mkhwanazi, 2014; Pournara, Hodgen, Adler & Pillay; 2015, Livy, Vale & Herbert, 2016; Aksu & Umit, 2016; Pournara, 2016). The key conundrum associated with this state of affairs is that there is a paucity of

substantial research on what this knowledge for teaching entails and how it is acquired during the learning to teach phase particularly in South Africa.

The establishment of sustainable communities of practice may serve to encourage teachers to work collaboratively for purposes of sharing expertise. In support of this notion, Pournara (2016) posits that engaging with peers' mathematical contributions serves to deepen content knowledge. The need to implore teachers to be reflective practitioners is paramount. This implies that problematic aspects associated with mathematics content have to identified and adequately addressed as part of continuous professional development interventions. Adler (2010) argues that some of the aspects requiring attention include mathematics for teaching, task design and attention to mathematical content, object and processes. These critical considerations ought to underpin far-reaching curriculum reforms which are essentially responsive to the critical needs of teachers and learners alike.

5. Conclusion

The prevalence of pervasive knowledge gaps associated with various FET mathematics exhibited by in-service teachers remains a key area of concern within the broader South African context. There is a critical need to put in place sustainable appropriate professional development interventions to enhance teachers' subject matter knowledge.

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