PEER OBSERVATION ON THE PEDAGOGICAL CONTENT KNOWLEDGE OF GRADE 11 NOVICE TEACHERS TO ENHANCE THE TEACHING OF STATISTICS IN A CIRCUIT

by

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ABSTRACT

This study focused on the peer observation of teaching [POT] on the pedagogical content knowledge [PCK] of mathematics novice teachers in the teaching of grade 11 statistics. A case study research method was conducted on this qualitative study. Two mathematics novice teachers were purposively selected from a population of five novice teachers from a circuit in Mpumalanga Province. Data were collected using semi-structured interviews, classroom observations and document analysis. Pre-lesson and post-lesson semi-structured interviews were conducted to obtain information about each teacher's views.

The POT process began with pre-observation meeting with the two novice teachers to discuss the modalities of the POT process and ended with the post-observation feedback meeting in which general evaluation and reflection of the process took place. Results show that the two mathematics novice teachers' classroom management skills improved. Furthermore, findings reveal that the two novice teachers improved in the use of instructional strategies as they moved from using teacher-centred strategies like the lecture method to using learner-centred instructional strategies such as oral probing and group work, among others, in which they interacted more with learners. The novice teachers also improved in identifying learners' misconceptions and learning difficulties. At the end of the study, the two novice teachers openly expressed that the POT process gave them the opportunity to improve in studying and teaching statistical content in depth.

DECLARATION

I, **Justine Chidziva,** declare that this research report is my original work and that I never plagiarised from any other source. This work is submitted in fulfilment of the requirements for the degree of Masters of Education at the University of South Africa, Pretoria. I would also like to declare that this work has never been submitted before to this university or any other institution.

Justine Chidziva

Signed at **Pretoria**

On 15 June 2017

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DEDICATION

I dedicate this thesis to my wife, Verna, family, siblings, children Tanaka, Taonaishe Lameck and Tatenda, and my mother, Lucia Chidziva, who was on wheelchair after suffering a stroke when I was compiling it.

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ABBREVIATIONS

AMESA-Association of Mathematics Educators of South Africa

ASA-American Statistical Association

CAPS-Curriculum and Assessment Policy Statement

CDE-Centre for Development Enterprise

DBE-Department of Basic Education

FET-Further Education and Training

GAISE-Guidelines for Assessment and Instruction in Statistics Education

IASE-International Association of Statistical Education

INSET-In-Service Training

ISI-International Statistical Institute

ISTE-Institute of Science and Technology Education

MKT-Mathematical Knowledge for Teaching

PCK-Pedagogical Content Knowledge

POT-Peer Observation of Teaching

SKT-Statistical Knowledge for Teaching

TSPCK- Topic Specific Pedagogical Content Knowledge

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CHAPTER ONE

INTRODUCTION

1.1 Overview of the study

This study is divided into five progressive and incremental chapters. The first chapter introduces the study. In this chapter, I present the introduction and overview, background to the study and the statement of the problem. The same chapter also presents research questions, objectives, significance of study, summary of literature review, research design and the chapter's conclusion. The second chapter presents review of related literature. Research methodology, data presentation and analysis procedures are examined in the third chapter. The data I gathered during fieldwork is presented and analysed in the fourth chapter. The fifth chapter contains the conclusions and recommendations.

1.2 Introduction

The study of mathematics has been promoted in many education systems around the world. The reason behind this thrust is that this discipline is paramount in industrial, technological, scientific and economic advancement of any nation. As a developing country, South Africa has made strategic moves to promote the study of the subject right from primary school up to higher institutions of learning. The Department of Basic Education [DBE] (2011a) mentions that mathematics is a compulsory subject to all South African children from Grade R to Grade 9. From grade 10 -12, learners either register to study mathematics or mathematical literacy. This is done to ensure and promote critical reasoning and an inquiry mind in all citizens.

Statistics, which is a new topic at secondary school level, is also part of the mathematics curriculum. According to Watson (1998), statistics was introduced into schools' mathematics curriculum in various countries at the beginning of the 1990s. Batanero (2012) points out that in several countries statistics has also been incorporated into the mathematics curriculum at high school level. According to Batanero, Godino and Roa (2004), the incorporation of statistics in the mathematics

curriculum at high school level is attributable to research studies which emphasize the importance of statistical reasoning and statistical knowledge in the society, its vital role in other disciplines and the need for a basic statistical knowledge in many workplaces. Because statistics is part of the mathematics curriculum, the mathematics teacher is expected to be well versed in both mathematics and statistics.

Mathematics is an abstract subject which requires that strategies be put in place to help learners understand its content. It is therefore the responsibility of the teacher to encourage students to engage in critical and analytic thinking. According to Attard (2011), teachers have powerful influences on students' achievements and study of mathematics, so it would require motivational skills to influence the students in a positive way to acquire desirable results. Woolfolk (2010) argues that good teachers use pedagogical skills to help learners understand abstract concepts.

According to Ning (2009), there is a gap between teachers' pedagogical content knowledge [PCK] and how they impart knowledge to learners in class. Shulman (1986:9) defines pedagogical content knowledge as "the ways of representing and formulating the subject making it comprehensible to others". It is evident that teachers have to contend with the challenge of making the subject matter to be understood by learners. Sibuyi (2012) emphasizes that teachers should have deep understanding and knowledge about what they have to teach. When they do this they would be understood better and the instructional process becomes more effective. For effective teaching and learning to take place, the teacher should be empowered with specific skills in the process. Empowered people feel that they can participate actively and make a contribution to make a difference (Carl, 2010). In South Africa, teachers have been given curriculum support by means of curriculum workshops organized by the DBE, teacher unions, non-governmental organizations and other stakeholders. Some teachers also take part in marking of national examinations.

According to Human Sciences Research Council [HSRC] (2011), South Africa was one of the lowest performing countries in mathematics in international assessments administered to Grade 9 learners in comparison with other countries. The report shows that a lot of effort has to be exerted nationally to improve the quality of

teaching and learning of mathematics at all the levels. The Centre for Development Enterprise [CDE] (2011) report mentions that the quality of South African school teachers is one of the poorest in the developing world as compared to other countries. This report reveals that the existing teachers are not teaching the subject matter well and that is why the performance of learners in schools was not impressive.

In the announcement of national Grade 12 results for 2013, the South African Minister of Basic Education stated that though there was improvement in results as compared to previous years, there is need to exert concerted efforts in mathematics and science in order to improve the quality of results. The Minister continued to reiterate that performance in mathematics in the national examinations was still facing a decline (DBE, 2015). Mpumalanga, one of the nine provinces of South Africa composed of four districts, has also faced a lot of challenges in the performance of Grade 12 learners in mathematics.

Records indicate that the district in which this study was conducted, had the lowest performance in the province for three consecutive years 2013, 2014 and 2015 (DBE, 2014b; DBE, 2015; DBE, 2016). A certain circuit, which was the site of this study, is situated in the district where results in mathematics national examinations were not impressive. The table below shows performances of the four districts of Mpumalanga Province in National Senior Certificate mathematics examinations in 2013, 2014 and 2015.

Table 1.1: Pass rates per district

Sources DBE (2014b), DBE (2015) & MPDBE (2016)

	Percentage pass rate in grade 12 mathematics national examinations in 2013, 2014 and 2015		
District	**2013**	**2014**	**2015**
District A	41.1%	40.5%	40.3%
District B	61.2%	58.8%	57.8%
District C	63.6%	62.1%	56.4%
District D	65.7%	62.7%	65.8%
Mpumalanga Province	**58.3%**	**56.3%**	**55.5%**
National	**59.1%**	**53.5%**	**49.1%**

A study conducted in one of the circuits in this district reveals that the poor performance in mathematics and science is attributable to teachers' lack of knowledge of mathematics and lack of teaching skills of the subject (Sibuyi, 2012). The majority of teachers lack pedagogical knowledge of what they have to teach and how to teach the subject content in an effective way (Adedoyn, 2011). Sibuyi (2012) argues that novice teachers often struggle to present concepts in a manner that is comprehensible to the students because they have little or no PCK. The author continues to argue that at universities and colleges these teachers learnt content and theory of classroom practice but as they come into the teaching profession, they face the challenge of converting theory into practice. I have a view that one of the reasons for the poor performance in grade 12 mathematics examinations might be that the district under study was recruiting new mathematics teachers from universities and colleges. The new teachers became novice teachers as a result. A novice teacher in this study is any teacher with less than five years teaching experience (Kim and Roth, 2011). The novice teachers were recruited in schools where they would not find qualified experienced mathematics teachers to assist them because research shows that PCK develops with more classroom practice and experience (De Jong, 2010; Schneider and Plasman, 2011).

According to DBE (2009), prospective teachers were trained through bursaries provided by the Department of Basic Education to study at universities and colleges. DBE (2009) also reports that it funded prospective teachers' training through a programme called Funza Lushaka, which was aimed at addressing the shortage of teachers in mathematics, science and other learning areas which were identified as critical subjects. Students were sent to study at universities and colleges around the country to train as teachers and after graduating they were employed to teach in the schools where the shortage of teachers was experienced. Also, other teachers were produced by universities and colleges through other bursary programmes funded by the DBE, non-governmental organizations, the corporate institutions and other stakeholders.

Batanero (2012) argues that in many countries, South Africa included, few teacher training programmes prepare teachers who are competent to teach statistics because the majority of them are trained to teach mathematics. In addition, research has shown that programmes which produced teachers at 21 universities in South

Africa are not very effective in preparing teachers' content knowledge and PCK in statistics (Wessels, 2008). In support of Wessel's argument, Ingersoll and Strong (2011) contend that pre-employment teacher preparation is rarely sufficient to provide all the knowledge and skills necessary for successful teaching. A significant portion can only be acquired while on the job. In my view, this implies that the more a teacher gains experience in classroom teaching, the more he or she develops his or her own PCK. This also implies that novice teachers still need to be exposed to classroom situations to enhance their PCK development as they have less classroom experience. Williams, Eames, Hume and Lockley (2012) posit that in recent studies, expert teachers are not born with PCK, and it is a lengthy process for novice teachers to acquire skills and new knowledge needed to become professional teachers who are experts in the field. In my view, novice teachers might also have faced challenges in the teaching and learning of statistics because of not having knowledgeable experienced colleagues around them.

According to Ijeh (2012), teaching statistics requires that a teacher uses topic-specific instructional skills and strategies. A teacher should be able to present to learners' problems to solve while he or she monitors and guides them. The teacher should use learner-centered strategies like individualized instruction, the discovery method and extra tutoring, among others. In 2005, the Guidelines for Assessment and Instruction in Statistics Education [GAISE] were approved by the Board of Directors of the American Statistical Association [ASA] for both the K-12 and college levels. GAISE was an attempt to make the need for reform more visible and to make recommendations about important features of a modern, introductory statistics class. When teachers apply recommendations of GAISE report, their practice becomes vibrant and effective.

The GAISE college report (ASA, 2005) prescribed a set of guidelines for teaching the introductory, college statistics course and included six basic recommendations:

1. Emphasize statistical literacy and develop statistical thinking.

According to Batanero and Diaz (2010), statistical literacy involves the understanding of basic language of statistics and fundamental ideas. In order to be statistically literate, it is imperative that teachers are exposed to statistical projects and investigations to develop statistical thinking (ASA, 2005).

2. Use real data.

Teachers in their classrooms provide data from real life situations obtained from textbooks, websites and other sources to allow learners to appreciate the importance of statistics. Batanero and Diaz (2010) argue that the engagement of statistical agencies to provide real life situations develops teachers' understanding of statistics.

3. Stress conceptual understanding rather than mere knowledge of procedures.

Teachers should be able to explain concepts to learners and teach them how to use these concepts in solving statistical problems. According to Mills (2015), the primary goal of the teacher should be to make students understand statistical concepts and use them to solve exercises than to memorize formulae and procedures without understanding these concepts.

4. Foster active learning in the classroom.

Teachers are encouraged to use student centered approaches like problem solving, discussion groups, clickers and make students look for data themselves to allow learners to understand statistical content. The use of student centered teaching strategies facilitates active participation of students in class.

5. Use technology for developing conceptual understanding and analyzing data.

Teachers are encouraged to use computers, perform simulations, use spreadsheets and other forms of technology to facilitate effective teaching and learning of statistics. Lee and Hollerbrands (2008) argue that the use of technology to explain statistical concepts in the classroom allows learners to understand and develop more statistical ideas.

6. Integrate assessments that are aligned with course goals to improve as well as evaluate student learning.

Teachers should use effective assessment strategies like homework, quizzes, written reports and oral presentations, among others, to facilitate learner comprehension.

According to research, novice teachers lack PCK (Sibuyi, 2012; Berry, Bol and Mckinney, 2009; Ham, 2011; Usak, 2009; Ong, Lim and Ghazali, 2010). The researcher has the view that novice teachers might face challenges in implementing the GAISE guidelines. Furthermore, novice teachers might face challenges like lack of textbooks and computers or lack of exposure to statistics agencies to assist in obtaining real data to use in their classrooms. It is also my view that when novice

teachers adopt the skills recommended in the GAISE report, the teaching and learning of statistics becomes effective. This study sought to explore how peer observation on the PCK of novice teachers in teaching Grade 11 statistics in a Circuit in Mpumalanga Province could enhance the teaching of statistics.

1.3 Background of the problem

From my experience as a mathematics educator, I observed that some learners could not solve tasks based on data handling and probability. One of the reasons might be that some teachers were not trained to handle such topics. According to Makwakwa (2012), the topics data handling and probability had been taught in tertiary education only as components of statistics. Before the advent of democracy in South Africa, data handling and probability teachers were never trained at colleges of education to teach the content; so the majority of mathematics teachers in South Africa in the Further Education and Training [FET] band met statistics for the first time in 2006 (Makwakwa and Mogari, 2012; DBE, 2012). These teachers who had no background in the teaching of statistics and probability were given a grace period until 2010 to acquire the requisite knowledge to teach all topics in the mathematics curriculum effectively. A lot of intervention workshops, seminars and in-service training programmes [INSET] were organised to develop teachers' content and pedagogical knowledge in statistics (DoE, 2008). Statistics was chosen because it was new in the South African mathematics curriculum and many teachers may not have enough experience in the teaching and learning of this topic.

According to Makwakwa (2012), despite all interventions to improve pedagogical content knowledge and content knowledge of teachers, little progress had been attained to improve their performance. This was a result of teachers' inability to follow policy documents, failure to use resources effectively and slow rate to acquire new information. Makwakwa (2012) mentions that there were other in-service training [INSET] programmes aimed at providing teachers with the necessary content knowledge and skills to teach data handling, organized mainly by non-governmental and governmental organizations such as the South African Statistical Association (SASA), Statistics South Africa (Stats SA) and the Association for Mathematics Educators of South Africa (AMESA). The Institute for Science and Technology Education (ISTE) at the University of South Africa also held lessons in

Gauteng Province during school winter vacations to mathematics teachers on data handling and probability in a bid to improve teachers' knowledge of data handling and probability content and other mathematics topics (Atagana, Mogari, Kriek, Ochonogor, Ogbonnaya & Dhlamini, 2010 & Makwakwa, 2010). According to Atagana *et al* (2010), even though ISTE's in-service initiative has been taking place annually since 2009, there were teachers who still had difficulties with teaching data handling and probability.

However, each year Grade 12 results indicate that learners had been performing poorly on the question in data handling items in the National Senior Certificate examinations at national and provincial level (DBE, 2013; DBE, 2014a; DBE, 2015 and DBE, 2016). These documents give evidence that there were challenges faced in teaching and learning of data handling in South Africa. According to DBE (2011b), the Mathematics Paper 2 examination for Grade 12 is marked out of 150 marks. Questions on statistics are allocated an average of 20 marks out of the150. Below is a table showing the average mark in percentage per topic in National Senior Certificate Examinations for Mathematics Paper 2 from 2013 to 2015. The average marks were calculated by the researcher from the information in the diagnostic reports.

Table 1.2: Average mark in percentage per topic in National Senior Certificate Examination

Topic	2013 Average mark calculated from DBE(2014a)	2014 Average mark Calculated from DBE(2015)	2015 Average mark Calculated from DBE(2016)
Data Handling	46.1%	65%	52.5%
Analytical Geometry	47.9%	49.5%	57.5%
Trigonometry	28.8%	42.7%	43.3%
Euclidean Geometry	Not in the syllabus	43.7%	37.8%
Transformation Geometry	28%	Removed from syllabus	Removed from syllabus

Table 1.2 above shows that performance in data handling from 2013 to 2015 was just as poor as in other topics. One would have an opinion that data handling was a simple topic as compared to other topics in Mathematics Paper 2, but in reality,

learners performed poorly in the topic just like in other topics in the national examinations. The learners committed a lot of errors in answering questions on data handling in the national examination. They faced a lot of challenges like confusing mean and median, inability to draw cumulative frequency curves and identify the median and quartiles from the ogive, poor use of calculators in determining variance and standard deviation, inability to work with box and whisker diagrams inclusive of five-member summary and misunderstanding of regression (DBE, 2013; DBE, 2014; DBE, 2015 and DBE, 2016).

It is therefore evident that statistics is one of the key topics in the curriculum which needs a lot of attention lest learners would continue to perform below standard. There is need to empower and capacitate teachers in the topic so as to improve the performance of learners in examinations. DBE (2014b) confirms that the quality of teaching in mathematics is a result of the shortage of suitably qualified teachers; some teachers never had academic and professional training to teach mathematics and others are outperformed by learners. In a nutshell, this signifies that some teachers lack PCK in the teaching of statistics.

Some in-service teachers were trained to teach statistics by means of INSET programmes and workshops since 2006. Those joining the teaching profession as novice teachers would need to be catered for as well. Workshops and INSET programmes were carried out by the DBE and other stakeholders on teachers and these were time consuming and still left teachers with some problems. The researcher was of the opinion that a convenient and appropriate way was required to support or come to the rescue of the DBE to capacitate the teachers.

1.4 Problem statement

There existed some disparities between teachers' mathematics content knowledge received during pre-service training and the mathematics content these teachers were expected to teach according to the South African mathematics curriculum at secondary school level. The curriculum expected teachers to teach mathematics content including statistics but the majority of mathematics teachers never trained to teach statistics. Since in the country there was shortage of qualified mathematics teachers, these teachers were compelled to teach the mathematics content inclusive

of statistics which they were never trained to teach. Statistics was not part of the mathematics content when these teachers underwent training. In addition, novice teachers who never had a strong university or college preparation to teach statistics joined the teaching profession where they found experienced teachers struggling with the teaching of the content. Such teachers required support and guidance from in-service teachers who had been empowered to teach this section through workshops organised by the Department of Basic Education. This study therefore sought to explore the how peer observation of teaching [POT] on the PCK of mathematics novice teachers in teaching Grade 11 statistics in a circuit in Mpumalanga Province can enhance the teaching of mathematics.

1.5 Aim and objectives of the study

The aim of the study was to explore how peer observation of teaching on the PCK of mathematics novice teachers in teaching Grade 11 statistics in a circuit enhances the teaching of mathematics. This study therefore sought to:

1.5.1 Determine the activities that favour peer observation of teaching for improving novice teachers' PCK in teaching Grade 11 statistics.

1.5.2 Determine the nature of improvement on the mathematics novice teachers' PCK in teaching grade 11 statistics.

1.5.3 Determine how peer observation of teaching of novice teachers improves the teaching of grade 11 statistics.

1.6 Research Questions

The main research question of the study was:

How does peer observation of teaching on the PCK of novice teachers in teaching Grade 11 statistics enhance the teaching of mathematics in a circuit?

In the study the following sub-questions were asked:

a) What activities favoured peer observation of teaching for improving novice teachers' PCK in teaching Grade 11 statistics?
b) What was the nature of improvement on the novice teachers' PCK in teaching statistics?

c) How does peer observation of teaching of novice teachers improve the teaching of grade 11 statistics?

1.7 Significance of the study

This study explored how peer observation on the PCK of novice teachers in teaching Grade 11 statistics in a circuit in Mpumalanga Province could enhance the teaching of mathematics. This study would help subject heads of department (HODs) in the schools in assisting in improving pedagogical skills of these teachers in the teaching of statistics. Novice teachers would be assisted in developing strategies to improve the quality of teaching and learning of statistics. The novice teachers would learn which methods of solution are easier and effective to teach learners in order for them to answer examination questions. This would ultimately help to improve the quality of answers learners write in the national examinations. I believe the study would also give insight and knowledge to schools about the importance of peer observation and collaboration in the teaching of statistics and other topics in mathematics. Teacher training institutions may find the study informative and try to find ways in preparing effective mathematics teachers who are able to teach statistics. This study would provide knowledge on how to support novice teachers in order to improve the likelihood of them staying on the job and to avoid high attrition rates by these teachers.

1.8 Literature Review

According to Wessels (2011), mathematics teachers in South Africa before 2006, were not yet statistically literate and lacked confidence to teach statistics because statistics education was still in its infancy stage and much had to be done to prepare mathematics teachers on the broad statistics curriculum to promote statistical literacy. In pre-democracy South Africa, data handling was taught using traditional methods aimed at carrying out simple statistical tasks like drawing simple graphs of already organized data sets and describing simple data sets by calculating mean, mode and median (North and Zewotir, 2006). Therefore, it means in pre-democracy South Africa, rote learning was prevalent and could not give learners the room to develop the inquiry mind and critical thinking and reasoning. According to Batanero

and Diaz (2010), statistics was introduced into the school curriculum because of its inherent importance in everyday life, its ability to develop critical reasoning and its usefulness in other disciplines.

Mathematics is a subject that facilitates creative, critical and logical reasoning about problems in the physical and social world in the context of mathematics itself (DBE, 2009). According North and Zewotir (2006), the curriculum has since been revised to include the collection, representation and critical analysis of data to draw conclusions, predict and determine chance variation and problem solving.

The teaching and learning of statistics in South Africa has had its own challenges owing to the newness of the content in the curriculum and also how teachers were trained at universities and colleges. According to Wessels (2008), a survey was conducted on mathematics lecturers of 21 universities in South Africa. The lecturers were requested to describe statistics content and PCK of the following courses: Bachelor of Education [BEd] with specialization in Mathematics, Advanced Certificate in Education [ACE] in Mathematics and Postgraduate Certificate in Education [PGCE]. The following results were obtained:

- The lecturers agreed that teachers of the Intermediate phase and senior phase lacked basic sufficient content knowledge in statistics
- Many of the programmes did not prepare teachers adequately to teach statistics.

The findings above suggest that new mathematics teachers who would enter into the teaching profession lacked PCK in the teaching of statistics. In other words, novice mathematics teachers require support in the teaching and learning of statistics because they lack PCK. Meyer (2004) argues that the process of learning to teach is complex and novices are limited by their lack of background experience as teachers and therefore have limited frameworks for making sense of what is happening in their classrooms.

Novice teachers suffer from stress and always ponder quitting teaching because of weak socialization structures (Joiner and Edwards, 2008). The researchers contend that surface-level orientations and induction programmes for novice teachers are not adequate because they leave the novice teachers with little knowledge of how to cover the entire curriculum. There is lack of mentoring, unsuccessful matching of

mentors and mentees and lack of understanding of the mentoring process. Pre-employment teacher preparation is rarely sufficient to provide all the knowledge and skills necessary for successful teaching and a significant portion can only be acquired while on the job (Ingersoll and Strong, 2011). Hence schools have to provide environments where novices are able to learn the art of teaching and become experts in classroom practice. Novice teachers and pre-service teachers lack exposure to students, making it difficult for them to understand how content and pedagogy connect to student learning. Research studies carried out show that pre-service teachers and novice teachers are not aware of the possible alternative conceptions that their students might have (Aydın, Boz and Boz, 2010; De Jong, 2010; Özden, Uşak and Eilks, 2008 and Uşak, 2009).

As explained, novice teachers lack PCK; they need support, and Rowe, Solomonides and Handal (2010) argue that peer observation of teaching [POT] is one effective way to support novice teachers. POT allows two or more teachers, either experienced or inexperienced or both, to work together in observing each other's teaching and then provide feedback and suggestions for improvement. Gosling (2002) outlines four models of peer observation of teaching which are:

(i) evaluation model which involves senior staff observing other teachers,
(ii) development model which involves expert teachers observing others,
(iii) peer review model which involves colleagues observing each other and
(iv) the peer development model in which colleagues engage in exploratory dialogue.

This study used the peer review model. The peer review model was used because it is a model that allows colleagues to observe one another in order to improve the quality of teaching and learning through open discussion. I used peer review because it gave the participants an opportunity to be open in their responses and also did not intimidate the participants. Effective peer review depends on establishing collegial trust and respect, providing guidelines and resources and embedding the process into performance management, promotion and recognition policies (Harris, Farrel, Bell, Devlin and James, 2008). According to Spiller (2011), the use of peers with the objective of improving classroom practice is recommended. Teachers will meet and discuss their findings and discuss constructive feedback. It is

a collaborative and reciprocal process whereby one peer observes another's teaching whether actual or virtual and provides supportive and constructive feedback (Lublin, 2002).

Several authors have highlighted the importance of POT; it cultivates a collegial atmosphere through dialogue about common issues of concern and improves the quality of teaching and learning through systematic discussion and critique (Rowe *et al* 2010; Spiller, 2011 and Thúy, 2012). Thúy (2012) and Rowe *et al* (2010) mention that POT provides self-awareness about a variety of instructional aspects of classroom practice like methods of instruction, among others. Colleagues have an opportunity to highlight on the areas of improvement in their peer (Hendry & Oliver, 2012 and Hirsch, 2011). According to Bovill (2011), POT helps to enhance the value of teaching and helps re-assure staff that their teaching is seen positively by their peers. On the other hand, it will be useful in helping to reveal hidden behaviour that individuals may not be aware of it.

However, peer observation has its own shortcomings. Researchers (Moore, 2013; Thúy, 2012 and Gosling, 2002) note that peer observation is time-consuming while others (Rowe *et al*, 2010; Moore, 2013 and Thúy, 2012) observe that usually the person being observed feels threatened and becomes nervous. Moore (2013) states that the lack of confidentiality makes peer-observation less effective as a tool to improve the quality of teaching and learning. Thúy (2012) makes a concern that sometimes feedback given may be biased and not genuine. Though peer review is a versatile method, Farrell (2011) suggests that it only works if colleagues respectfully acknowledge that there are diverse approaches to teaching and inform their processes of designing strategies to address any areas for improvement. During the study, I took into consideration the shortcomings mentioned above by establishing amicable relations with the participants well before the study began. The participants were invited to observe me delivering lessons and engaged in free and open discussions on what was observed. I always would encourage the observers to be sincere in their criticism whenever they conducted lesson observations to encourage development. This was done to avoid suspicion and uneasiness in the participants, build confidence and create rapport in the participants.

1.9 Conceptual framework for the study

This study was conceptualised on the basis of Shulman (1986) who argued the existence of PCK, which is knowledge which goes beyond content knowledge to include the dimension of subject matter knowledge for teaching. This knowledge is appropriate for the teacher to employ when imparting knowledge to students making it a point that what he or she explains is understood by the recipients. The key elements to Shulman's conception include:

1. Knowledge of the representation of the subject matter knowledge for teaching;
2. Knowledge of relevant instructional strategies; and
3. Knowledge of learners' conceptions (pre-conceptions and misconceptions) and learners' learning difficulties.

Shulman (1986) argues that PCK is an amalgam of content knowledge and pedagogical knowledge that enables the transformation of the subject matter knowledge into pedagogically useful forms. In support of Shulman, Karaman (2012) emphasizes that PCK is an indispensable attribute to a teacher because it enables him or her to organize lessons, develop understandable representations of topics be taught and understand possible difficulties students might encounter. A broader view of this theory is presented and discussed in Chapter 3.

1.10 Research design and methodology

The study used the qualitative research approach, which enables researchers to understand and explore the richness, depth, context and complexity which teachers on the research site operate (Mason, 2006). The Case Study design was used in this research. It was used to gain insight and explore PCK of novice mathematics teachers in the classroom and identify other aspects of PCK which require improvement.

1.11 Population and sample of the study

The population of the study was five mathematics novice teachers from a chosen circuit of ten secondary schools at the time when the study was conducted. Two novice mathematics teachers from two different schools in the chosen circuit were

selected through the purposive sampling technique, which is based on the judgment of the researcher. This technique allowed me to select a sample that is representative of the population. It is sampling that enables the researcher to choose the individuals or small groups from which he or she thinks important information can be obtained.

1.12 Data collection

Data was collected from participants using semi-structured interviews, classroom lesson observation and document analysis. To get access to documents, permission was sought first from the Mpumalanga Department of Basic Education, principals and participants before data collection commenced. Lessons were video recorded. All the field notes were kept for future use in data analysis.

1.13 Data analysis

The study followed a qualitative data analysis where data collected from video recorded lessons observed from all interviews and document analysis were transcribed and analyzed using thematic analysis. Themes were developed on PCK aspects (Shulman, 1986) which were:

(i) Knowledge of subject matter which comprises teacher's understanding and procedural knowledge;

(ii) Knowledge of teaching strategies for example analyzing appropriate activities with use of real life examples and employment of a variety of strategies; and

(iii) Knowledge of learners' difficulties, conceptions and misconceptions.

Furthermore, themes developed from theories of peer observation of teaching were used in the data analysis. The themes were reviewed with reference to answering research questions to extract more meanings and patterns. They were later defined and named followed by the production of the final report.

1.14 Limitations of the study

The size of the sample which was used in the study was small. As such, the researcher could not make generalizations using the findings of this study. Simons (1996) and Flyvberg (2006) argue that it is impossible to generalize from a single case and also researchers use data collected from case studies to confirm their preconceived notions. The writers also argue that case studies are only suitable for exploratory studies and for more conclusive studies. Other methods should be used rather than case studies. Although the results could be applied for the circuit under study, they may not be generalized for other circuits. However, the researcher also used few peer observers to eliminate bias.

1.15 Validation of the instruments of the study

Interview questions were formulated in tandem with the research questions. A lecturer at a university evaluated the questions and gave a critique on the interview questions. The lecturer gave opinions of what to add and subtract and how to reformulate the questions. Data collected from interviews, lesson observations and document analysis were triangulated to increase the validity of the findings. An observation protocol was crafted. It was validated by the curriculum advisors and a lecturer at a university. On document analysis, the instrument was formulated using advice from curriculum advisors because they always visited schools with similar instruments to monitor on teachers' progress.

1.16 Trustworthiness of the study

Denzin & Lincoln (2011) explain that reliability of the study is synonymous with trustworthiness of study which is composed of dependability, credibility, transferability and confirmability. Dependability focuses on consistency of research results over a prolonged period of time. To ensure dependability, this study was conducted over a period of two weeks engaging with the participants. In addition, pre-lesson and post-lesson semi-structured interviews were conducted as well as lesson plan analysis. To ensure credibility, I video recorded lessons observed in order to revisit them in future for analysis. Furthermore, the researcher took field notes and cross-checked with the participants about what really transpired in the

lessons observed. Sibuyi (2012) explains that confirmability is achieved when there is link between results obtained and data collected. Confirmability in this study was established by keeping data collected safely for future access and inspection. According to Lincoln & Guba (1985), transferability refers to applicability of findings to another setting. This study used a case study design whose findings cannot be generalized to other settings.

1.17 Ethical considerations

After getting ethical clearance from University of South Africa [UNISA], the researcher wrote a letter to the Head of Department of Mpumalanga Department of Education requesting permission to carry out research in the circuit. In the application the researcher attached a research proposal and ethical clearance from UNISA. The permission was granted by the Head of Department of Mpumalanga Department of Basic Education. Letters to principals of selected schools seeking permission to use their schools, teachers and learners for research were then written after getting permission from the Department of Education.

Afterwards, letters to concerned selected novice teachers and parents of learners were written. The teachers were requested to fill in consent forms. In addition, parents of learners were requested to fill in consent forms. After all necessary permission had been granted, data collection started. Voluntary participation was ensured and the participants were informed that they would be free to withdraw from the study at any given time when they would feel so.

Participants were assured that their names would not appear in the dissertation or in any publications but pseudonyms would be used and that they would be informed formally about details of the findings by the researcher. In line with the research policy of Mpumalanga Department of Education, a copy of the final report would be sent to the Research Unit of the Department. The research findings would also be discussed with the school principals and the novice teacher. The consent and assent forms were signed by the addressee and co-signed by the researcher.

1.18 Definition of key terms used in the study

Knowledge of learners' conceptions

In this study, knowledge of learners' conceptions denotes teachers' awareness of learners' prior knowledge that may consist of preconceptions, misconceptions, learning difficulties and correct conceptions the learners might have which the teacher can use during lesson delivery and lesson planning for effective teaching.

Knowledge of subject matter

In this study, knowledge of subject matter refers to correct interpretation and application of mathematical facts, content, procedures, principles and relationships between concepts.

Misconceptions

In this study, the term misconceptions, refers to wrong facts and information that may arise from learner's prior experiences.

Novice teacher

In this study, a novice teacher is a mathematics teacher with less than five years of teaching experience.

Pedagogical content knowledge

In this study, pedagogical content knowledge is defined as an amalgam of specific content knowledge of mathematics and statistics, knowledge of teaching strategies and knowledge of learners' conceptions.

Peer observation of teaching

In this study, peer observation of teaching is where two or more colleagues collaborate in observing each other's teaching and provide feedback and suggestions for improvement.

Instructional strategies

In this study, teaching strategies refer to methods used by teachers to ensure that there is interaction between the teacher and learners.

Statistics

In this study, statistics is defined as a science of collecting, organizing, summarizing and analysing information to draw conclusions and answer questions.

1.19 Conclusion

In this chapter, I gave an overview to the study, introduction, and discussed the background of the study about the poor performance of learners in statistics. The objectives, problem statement, research questions, theoretical framework, significance of the study, summary of research design and literature, were also presented and highlighted. In the next chapter, I present literature review on PCK and the teaching and learning of statistics.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, peer observation of teaching [POT], elements of pedagogical content knowledge [PCK], the teaching and learning of mathematics and statistics and novice mathematics teachers are discussed. The chapter begins with the review of literature on POT, South African school curriculum in statistics and goes on to explain studies already conducted in the teaching and learning of statistics. Other aspects discussed in this chapter also are challenges faced by novice teachers as they join the teaching profession.

2.2 Peer observation of teaching

According researchers (Hendry *et al,* 2012; Eri, 2014 and Robinson, 2010), peer observation of teaching [POT] is a reciprocal process in which colleagues observe each other's teaching practice with the objective of improving the quality of teaching. Researchers (Hendry *et al*, 2012 and Robinson, 2010) explain that POT is a supportive and developmental tool for improving the quality of teaching in universities whereby colleagues give and receive feedback on the effectiveness of teaching practices for promoting student learning. According to Malderez (2003), POT as a tool for development and growth should be conducted by trusted by trusted colleagues and peers in order to eliminate the authoritative, supervisory and threatening aspect of the process.

Gebhard (1999) argues that peer observation and observation are two distinct processes with POT as a non-judgmental description of events that can be analysed and given interpretation, but observation is judgmental and used for appraisal. Keith (2007) explains that in a study carried out in Hong Kong teachers favoured peer observation since it is developmental in nature rather than appraisal.

According to Rayan (2013), POT should be carried out in a non-threatening environment and teachers who are committed to professional development should allow their colleagues to observe them. The process is very effective and can yield

excellent results if there is positive attitude among colleagues. Fernandez-Chung (2009) argues that for POT to be effective, the management of any institution should be involved to allow professional development.

Richards and Farrel (2005) in a study conducted in the United Kingdom on a pre-service program for teachers claim that POT has a number of benefits which include:

1. Assisting teachers to be aware of everyday classroom affairs and how to resolve them; and

2. Assisting in narrowing the gap between the teachers' theoretical views of teaching and what actually happens in the classroom.

This study implies that peer observation would be very beneficial to novice teachers to put into practice what they would have learnt at colleges and universities.

Day (2013) conducted a study to investigate the effectiveness of POT on 15 graduate students whose teaching experience ranged from zero to eight years in the teaching of English Language. Data was collected from the students by means of two questionnaires. The findings show that the students liked POT and they engaged in reflective teaching which allowed them to modify their teaching practices and beliefs. Furthermore, the students pledged that they would always engage in reflective teaching in future. Richards and Lockhart's (1996:1) reflective approach to teaching is when teachers "collect data about teaching, examine their attitudes, beliefs, assumptions and practices and use the information as a basis for critical reflection about teaching". However, Gün (2011) argues that although teacher education programs assist in reflective teaching, teachers are unable to engage in reflective teaching unless they are specifically trained on how to reflect.

According to Bell (2002), the POT process should consist of pre-observation meeting, observation, post-observation feedback meeting and reflection. Various researchers (Bovill, 2011; Robinson, 2010 & Semmoud, 2015) also suggest the POT process should consist of stages suggested by Bell (2002). Millis (1992) asserts that during the pre-observation meeting, the observer and the observed should clarify the procedure of the POT process, talk about the expectations and the logistics involved. Robinson (2010) explains that the stage of actual observation is when the observer takes detailed descriptive field notes on what really happens in the classroom. During the post-observation meeting, the teacher and the observer discuss

constructively about what transpired. The stage of reflection consists of the discussion and evaluation of the whole POT process.

Although POT has numerous benefits, some researchers (Bell and Cooper, 2013; Gosling, 2002 and Blackmore, 2005) argue that academics felt vulnerable and uneasy when colleagues observe them because they are used to conduct lessons without anyone observing them. Teachers and academics complain that their privacy is intruded when colleagues observe them. Iqbal (2013) also points out that the academic freedom and autonomy is undermined. According to Robinson (2010), POT is time-consuming and the process is susceptible to bias. The author argues that teachers may compare others to their own experiences making their own practices as standards with which to judge the performances of their colleagues.

Researchers (Hendry *et al,* 2012; Eri, 2014 and Robinson, 2010) argue that although POT has its own shortcomings, its benefits far outweigh these pitfalls because the quality of teaching is improved. In this study, the quality of teaching was viewed from the perspective of PCK of mathematics novice teachers in the teaching of statistics in Grade 11. Bodner and Orgill (2007) assert that PCK is the type of knowledge important for the novice teacher as he or she matures professionally to become an expert teacher. This view was critical to this study because it intended to explore how peer observation affected PCK of the mathematics novice teachers as he or they interacted with learners, curriculum, content and fellow teachers.

2.3 Statistics in the South African curriculum

According to Hassad (2009), the use of statistics dates back to the eighteenth century when it was referred to as political arithmetic because it was used in gathering and analysing of economic and population data. Due to intensive use and practice, it evolved into an independent scientific discipline which later was formalized in 1834 following the founding of the Royal Statistical Society [RSS]. However, Makwakwa (2012) argues that there is evidence that the use of statistics dates back to the era before Christ (BC) though there was intensive use of the discipline in 18^{th} century. The launch of mathematical statistics by John Graunt in 1662 influenced mathematicians like De Moivre, Laplace and Poisson, among

others, to shape and consolidate the discipline to the levels which we see statistics now.

According to Hassad (2009), other organizations started to come into existence like the American Statistical Association [ASA] founded in 1839, International Statistical Institute [ISI] founded in 1885 and International Association of Statistics Education [IASE] in 1991. Researchers (Makwakwa, 2012; Woolbridge and Gruic, 2012; Wegner, 2007 and Yadar, 2010) emphasize that statistics is very important because it pervades various spheres of human life and existence like health, agriculture, economics, crime rate and weather forecasting, among others.

According Batanero and Diaz (2010), statistics has a long history and tradition in schools in countries like Spain, France and the United Kingdom, and because of its increasing importance, it has been included in the curriculum of countries like Australia, South Africa, Brazil and United Arab Emirates. In the South African context, researchers (Makwakwa and Mogari, 2012) mention that in pre-democracy South Africa, statistics was only taught at universities and it was only introduced to schools in 2006. According to Batanero and Diaz (2010), the reasons for introducing statistics at secondary school level is that it promotes critical reasoning and also that it is also important in other disciplines.

According to DBE (2012), in the CAPS document, the specific skills related to statistics that are supposed to be inculcated into the students are:

1. to collect, analyze and organize quantitative data to evaluate and critique conclusions;
2. to use mathematical process skills to identify, investigate and solve problems creatively and critically;
3. to develop the correct use of the language of mathematics; and
4. to participate as responsible citizens in the life of local, national and global communities, and to communicate appropriately by using descriptions in words, graphs, symbols, tables and diagrams.

The above skills are naturally inherent in the study of statistics because they facilitate the collection, summary, organization and analysis of data. According to researchers (Makwakwa and Mogari 2012; Ijeh, 2012 and Makwakwa, 2012), the

teaching and learning of statistics has never been easy in South Africa because of lack of resources and teachers' lack of PCK. This study recognizes the importance of mathematics novice teachers as an important force in the teaching fraternity and tries to explore their PCK in the teaching and learning of statistics.

2.4 Conceptual framework

Various studies (Van Driel, Verloop and De Vos,1998; Grossman, 1990 and Watson, 2008) have developed models to explain the construct of PCK. Van Dijk (2009) defines PCK as topic-specific knowledge that involves the transformation of content and pedagogical knowledge into instruction. Researchers (Bishop and Denley, 2007; Gess-Newsome and Carlson, 2013 and McConnell, Parker and Eberhardt, 2013) have come up with examples of how PCK is important in the classroom. However, other researchers (Loughran, Gunstone, Berry, Milroy and Mulhall, 2000; Loughran, Mulhall and Berry, 2004; Baxter and Lederman, 1999; Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu, 2008) argue that difficulties have been encountered in the studies related to PCK due to the complex nature of PCK, because of different methods of analysis and data collection methods. To understand the nature of PCK, use of different instruments should be useful to capture participants' PCK. Loughran, Mulhall and Berry (2013) assert that there are a lot of views on PCK from various scholars and a lot of research has been carried out but there is dearth in providing concrete examples of PCK in subject areas on how successful and competent teachers teach particular topics in ways that promote learner performance.

Cankoy (2010) suggests that PCK is a set of special attributes that helps a teacher transfer knowledge to others. On the contrary, Sibuyi (2012) notes that PCK comprises knowledge of teaching strategies that include appropriate conceptual representations in order to address the problems of learners and avoid confusion on concepts and enhance understanding. It is therefore paramount and compulsory that a mathematics teacher should be well versed with the content and should be able to employ potent instructional methods to facilitate comprehensibility of the subject matter.

Most of the views from other researchers try to refine the construct of PCK postulated by Shulman (1986). According to Ijeh (2012), PCK is an amalgam of

subject matter knowledge, pedagogical knowledge, knowledge of learners' conceptions and learning difficulties. Hawkins (2012) conceptualizes PCK to consist of three important components: knowledge of mathematics, knowledge of teaching and knowledge of students. This view is subject-specific and very important to consider when dealing with mathematics topics like statistics at high school level. According to Hawkins (2012), the teacher should have dominion of the subject, its facts, its theorems and all axioms so that he or she can be able to impart to the learners. Figure 2 below illustrates a diagrammatic representation of Hawkins' view of PCK.

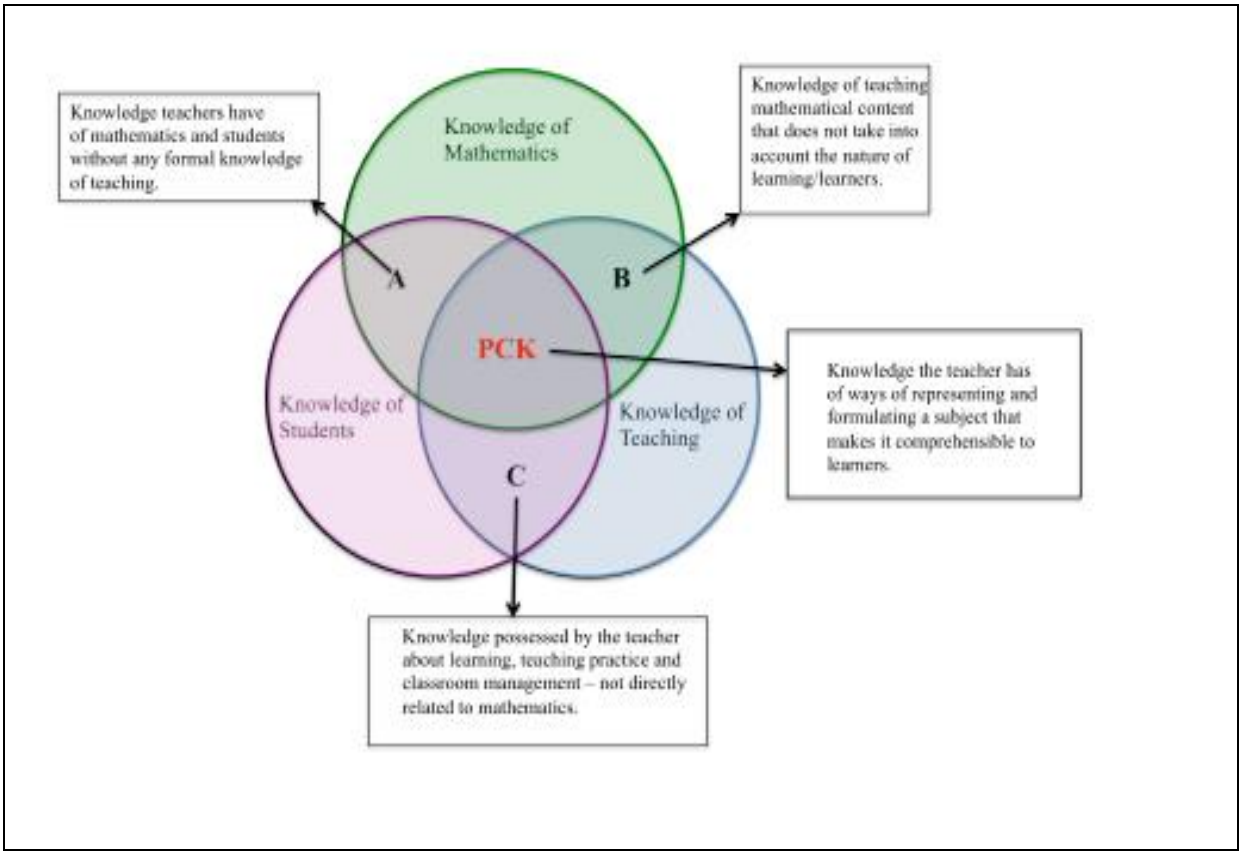


Figure 2.1: Diagrammatic representation of Hawkins' view of PCK

Etkina (2010) also presented PCK on teaching high school physics (see Fig 2.3 below). The researcher concludes that PCK consists of content knowledge [CK] and pedagogical knowledge [PK].

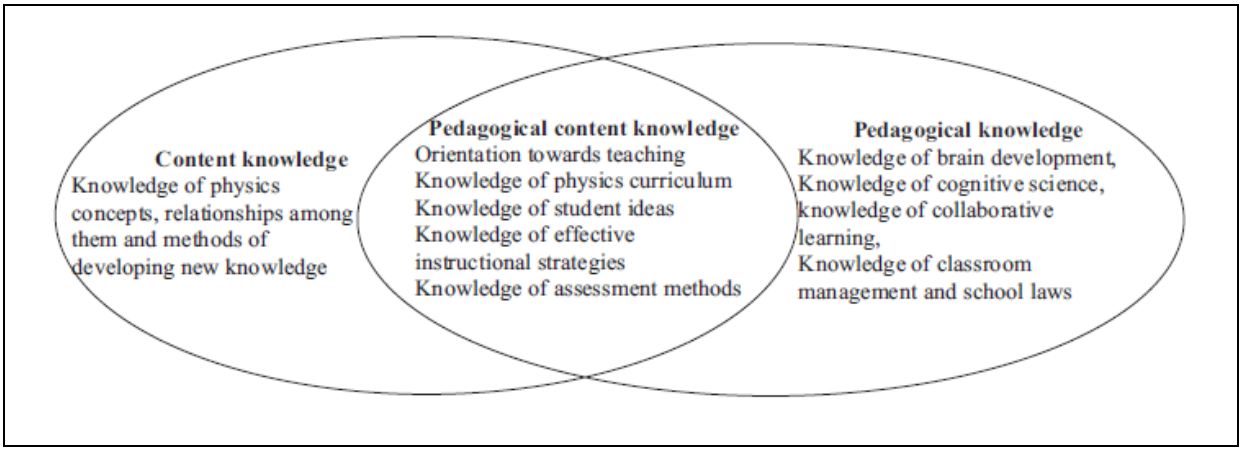


Figure 2.2: Structure of Physics teacher knowledge: Etkina (2010)

Adapting the view in Etkina (2010) to the teaching and learning of statistics, CK would consist of knowledge of statistics, concepts, relationships among them and methods of developing new knowledge. PCK according to this view comprises orientation towards teaching, knowledge of statistics curriculum, knowledge of student ideas, knowledge of effective instructional strategies and knowledge of assessment methods. This view emphasizes knowledge of statistics content, which according to literature is what some teachers lack. If the elements are put into practice, good results can be obtained especially that knowledge of assessment methods is highlighted. If good assessment methods are employed, learners would be prepared to write national examinations.

Another interesting perspective of PCK is highlighted in Gess-Newsome (1999). The author argues that PCK is a combination of subject matter knowledge [SMK], PK and contextual knowledge. It is similar to Etkina (2010) but includes contextual knowledge. This implies that a teacher needs to know the context in which the topic Statistics is done. The teacher should know the prevailing conditions in which he teaches the topic. Loughran *et al (2004)* also made a proposal to capture, document and portray science teachers' expert knowledge of teaching using the PCK construct. According to Loughran (2004), PCK consists of content representation [CoRe], Pedagogical and Professional experience Repertoires [PaPeRs] which comprise:

(i) Teaching objectives;

(ii) Knowledge of alternative students' conceptions;
(iii) Troubles that commonly appear during teaching and learning;
(iv) Effective sequencing of topic elements and important approaches to the framing of the idea;
(v) Use of appropriate analogies, demonstrations and examples; and
(vi) Insightful ways of students' assessment.

Loughran (2004) agrees with other authors, but mentions the use of appropriate examples, analogies and demonstrations. Effective teachers use concrete real life situations to make lessons interesting. If the novice in his or her journey in developing PCK would use real life situations, learners would inevitably benefit thereby enhancing performance.

In South Africa, a model was proposed linking what is observed in the classroom with PCK and the contributing fundamental knowledge bases (Davidowitz and Rollnick, 2011; Rollnick *et al*., 2008). They identified observable evidence and manifestations of the teachers' PCK and showed how these are linked to the contributing knowledge bases of subject matter knowledge, knowledge of pedagogy, students and context. According to Davidowitz and Rollnick (2011) and Rollnick *et al* (2008), the aspects of PCK which manifest in the classroom are:

(i) Representations;
(ii) Curricular saliency;
(iii) Explanations;
(iv) Interactions with students; and
(v) Topic-specific instructional strategies.

The authors propose that these aspects of PCK that manifest for a specific teacher depend on the topic and the context in which they are teaching and can vary from individual to individual.

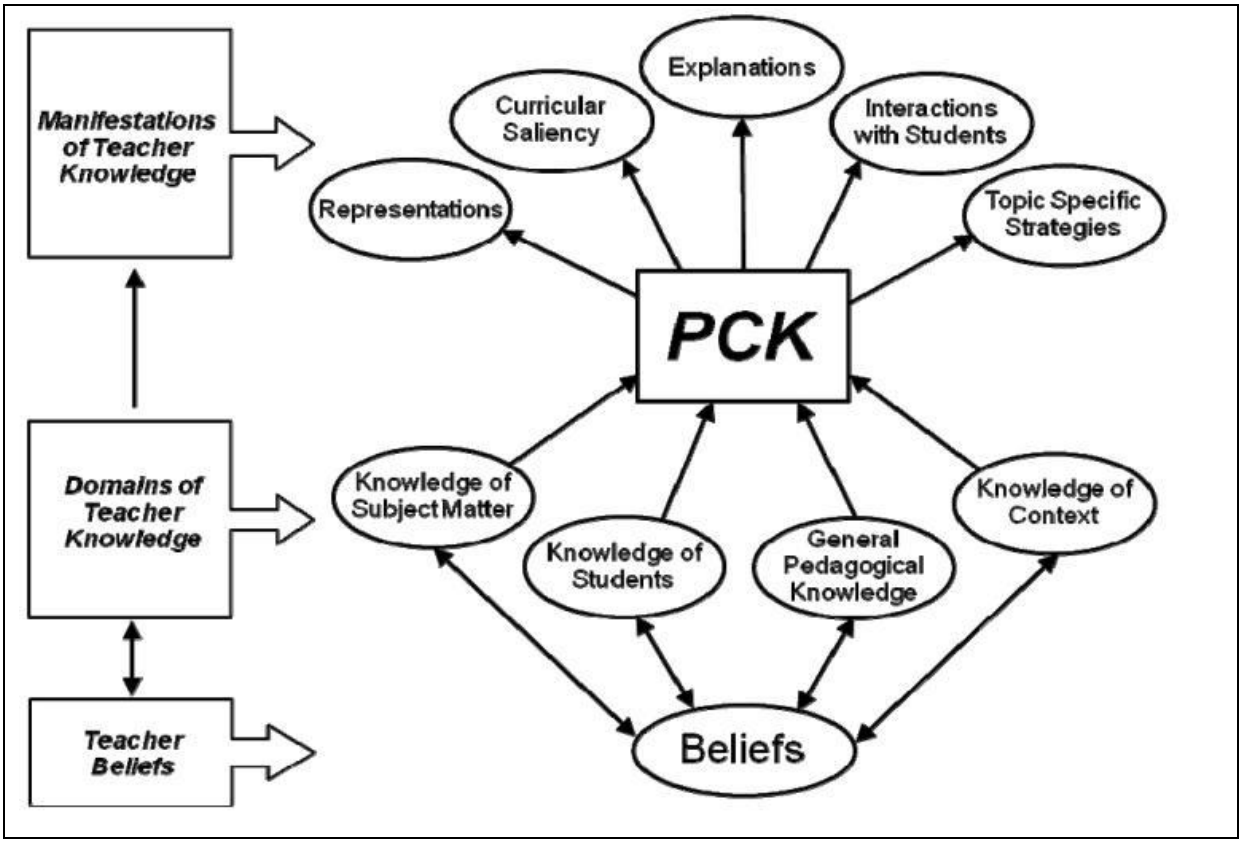


Figure 2.3: Rollnick *et al*.'s model of PCK (Davidowitz & Rollnick, 2011; Rollnick *et al*, 2008)

In a study on the teaching of electrochemistry carried out in Gauteng in South Africa, a special type of PCK called topic specific pedagogical content knowledge [TSPCK] was conceived (Mavhunga and Rollnick, 2013). When teachers reason about the teaching of a topic by considering the aspects of content knowledge, they transform the content knowledge and thereby develop TSPCK in the process. When we look at the teaching of statistics as a topic teachers need to be creative and use resources specific to statistics. They sit down and reason about how to impart each part of the topic in a comprehensible manner to the learners.

Various authors have given their views about pedagogical content knowledge which provide a firm theoretical base on the concept. Summarizing what other scholars have talked about PCK, it is indisputable that it revolves around knowledge of subject matter, knowledge of instructional strategies and knowledge of learners' perceptions.

On the teaching of statistics, Ijeh (2013) defines PCK as teacher knowledge that comprises components such as subject matter content knowledge in statistics, knowledge of learners' conceptions about the topic (statistics), knowledge of learners' learning difficulties in statistics and knowledge of instructional strategies. According to Makina (2013), PCK in statistics is knowing what, when and how to teach to make the subject comprehensible to others. The author goes on to explain that PCK is composed of the following:

1. Subject matter forms of representation with components such as analogies, illustrations, examples, explanations and demonstrations,
2. Knowledge of students' understanding with components such as conceptions and preconceptions, knowledge of curricula and understanding of what makes specific topics difficult and
3. Strategies to re-organise understanding comprising of general pedagogy.

However Batanero, Burrill and Reading (2011) view PCK in statistics as professional knowledge to teach statistics taking into consideration of aspects such as epistemology, instructional resources, knowledge about students' learning, ability to implement discourse in the classroom and ability to adapt to global school curricula and social factors. On the other hand Burgess (2008) defines PCK in statistics as a type of knowledge a teacher uses in the classroom by engaging learners in data analysis and technology. Burgess (2008) values the use of technology in the classroom to make statistics comprehensible to the learners. In a different view, Burgess (2006) asserts that PCK in statistics is teacher knowledge used in the classroom to promote statistical thinking and investigation. The author in this case presents a matrix composed of investigation cycles and four components of knowledge which are common content knowledge, specialised content knowledge, knowledge of content and students and knowledge of content and teaching to explain the concept of PCK in statistics teaching.

2.4.1 Knowledge of subject matter for teaching mathematics and statistics

According to Zerpa *et al* (2009), teachers need to have a deep conceptual understanding of the mathematics that they are teaching and must be able to illustrate why mathematical algorithms work and how these algorithms may be used

to solve problems in real life situations. This explanation implies that subject matter knowledge involves knowledge of all mathematical laws, axioms, concepts, theorems, representations and procedures. The teacher is expected to know all this material in order to have a firm foundation from which he or she has to spring in the instructional process. Content knowledge or subject matter knowledge refers to the amount of knowledge and organization of knowledge in the mind of the teacher (Banegas, 2009). According to the author, subject content involves all mathematical connections and entities in the mind of the teacher, which he or she has to convey and share with students in the classroom. So, interaction between the teacher and students is made possible through the sharing and transmission of the subject matter. Teachers without enough content knowledge spend more time learning the content instead of planning and preparing lessons to enhance students' understanding. Leong (2013) asserts that teachers with strong content knowledge are able to explain concepts instead of just mathematical procedures. More arguments forwarded by the author are that some believe that content knowledge and teaching strategies may be acquired in a quick and straight-forward way by beginning teachers.

Shulman (1986) suggests that content knowledge includes both the amount of the subject knowledge as well as organizing the structure of the subject. Ball *et al* (2008) developed the phrase "mathematical knowledge for teaching" (MKT) to refer to a special kind of knowledge required only for teaching mathematics.

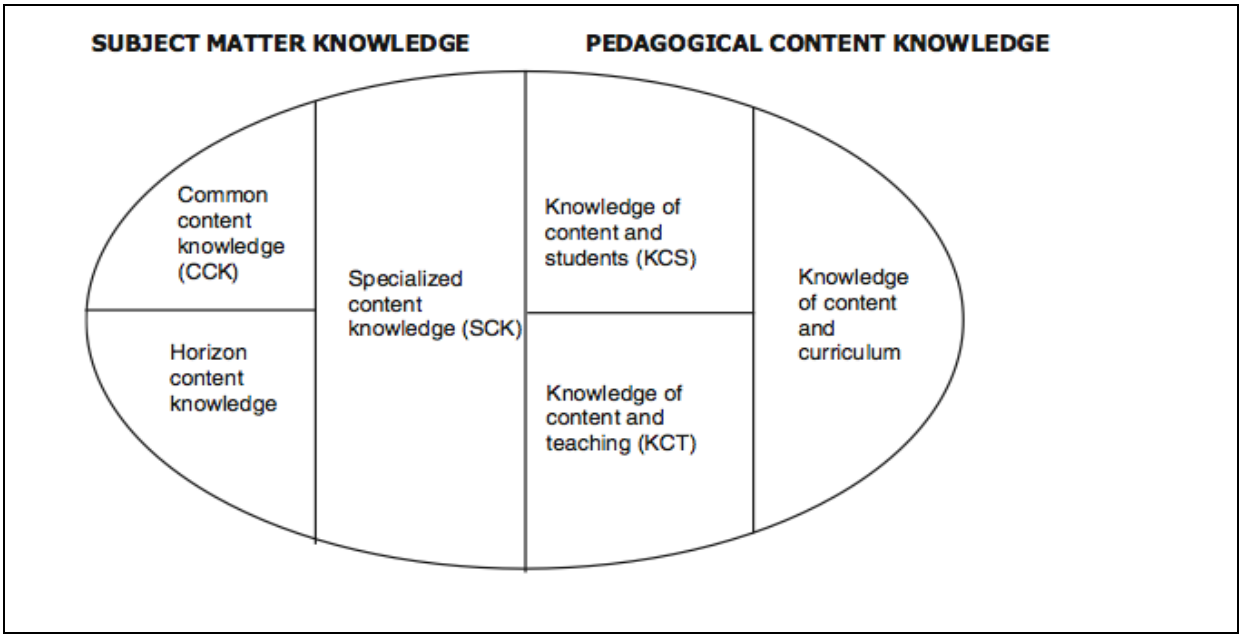


Figure 2.4: Model of Teachers' Mathematical Knowledge for Teaching (Ball *et al*, 2008:403)

In this view, subject matter knowledge consists of three sub-domains: common content knowledge (CCK), specialized content knowledge (SCK) and knowledge at the mathematical horizon. CCK refers to the mathematical knowledge and skills anyone can possess either a teacher or a student. Solving problems and knowledge of how to use mathematical procedures fall under CCK. SCK is knowledge only inherent in the teacher and not possessed by students. It involves teacher's ability to identify student errors or assessing whether a non-standard procedure would work or not. Ball *et al* (2008) also mention a special kind of subject matter knowledge called knowledge at the mathematical horizon. It is "an awareness of how mathematical topics are related over the span of mathematics included in the curriculum". It is closely related to a teacher's ability to draw concept maps, making links of concepts and content across the curriculum. According to Ball *et al* (2008), teachers should be able to know what is in the curriculum and the relationships of topics.

According to Groth (2007), there exist significant differences between the disciplines of statistics and mathematics that impact on the way the subject matter should be imparted to learners. Statistical knowledge for teaching (SKT) is a pivotal area of study distinct from research investigating MKT. Because "statistics utilizes mathematics," there is considerable overlap in the structure of the teaching of statistics and the teaching of mathematics. Groth (2007) suggests making use of Ball *et al* (2008)'s six components of MKT for use in statistics education research and he explains SKT as requisite knowledge for teachers of statistics in order to be effective in the teaching of the subject. SKT comprises, but is not limited to:

1. Knowledge of the concepts and procedures of statistics—statistical literacy and statistical thinking skills;
2. Analysis of statistical solutions to problems and determination of whether the results are reasonable and what types of thinking or analysis might lead to particular results;
3. Knowledge of informal and formal statistical inference ideas including connections between probability, sampling distributions, and statistical inference;

4. Ability to formulate questions, collect and analyze data and interpret results;
5. Ability to recognize and account for the key roles of context and variability in solving statistical problems, including formal procedures for calculating variability and conceptual ideas of variability;
6. Ability to recognize the crucial role language plays in expressing statistical ideas;
7. Ability to recognize common student misconceptions and understand how students come to learn specific statistics content; and
8. Ability to manage productive class discussions about statistics and answer student questions.

The list outlined above represents a synthesis of numerous recommendations from statistics education researchers (Franklin and Garfield, 2006; Garfield and Ben-Zvi, 2008; Groth, 2007; Chance, Medina and Rossman, 2006) regarding the teaching and learning of statistics.

Subject matter knowledge is disciplinary knowledge obtained through formal training at universities and colleges while pedagogical knowledge entails knowledge of instruction required by the teacher in the interaction with students in the classroom every day (Ijeh, 2012). This argument presented by Ijeh (2012) suggests that pre-service training of teachers is of primordial importance in acquiring subject matter knowledge. Those preparing to become future teachers of statistics should work very hard to acquire this knowledge while still training so that they will be well versed in ways to explain to the students in future when they would start as novice mathematics and statistics teachers.

Mishra and Koehler (2006), in their study for investigating teacher knowledge, suggest that subject matter knowledge is the actual matter or content to be taught. They also agree that teachers must know and understand the mathematics they teach, inclusive of the knowledge of key facts, theorems, theories, procedures and rules and evidence of proofs. Schneider and Stern (2008) view conceptual knowledge as knowledge of core concepts and principles together with relationships and interrelations in the mathematics domain. Kilic (2011) argues that a good conceptual understanding of topics, relations and procedures will assist teachers to detect the misconceptions, misunderstandings and confusion which students might have. However, Engelbrecht, Harding and Potgieter (2005) and Star (2002) affirm

that a combination of both procedural knowledge and conceptual knowledge is more effective because it creates more opportunities for learners to improve conceptual understanding of mathematics during a lesson. Sibuyi (2012) posits that a teacher's subject matter knowledge can be assessed by checking the accuracy of mathematical facts, flexibility in making explanations, sequential presentation of facts and fluency in presenting the lessons.

2.4.2 Knowledge of learners' conceptions, misconceptions and perceptions

Sibuyi (2012) describes knowledge of learners' conceptions, misconceptions and preconceptions as knowledge about characteristics of a certain group of learners, how they behave, what they believe in and how they view mathematics and knowledge of their cognitive problems as individuals or as a group. When the teacher knows all these things he or she would know what content to teach at the right time and make a suitable approach commensurate with how learners view mathematics. Analysing the view above, it suggests that the novice mathematics teachers should acquire skills to detect learners' misconceptions and errors while teaching so that he or she corrects these in order to allow the learners to understand the topic. According to Ryan and Mcrae (2009), knowledge of common mathematical errors and misconceptions gives information to teachers about students' thinking and find ways to assist them to rectify these errors. The authors explain that when teachers use baseline assessment they want to check on the misconceptions about a particular topic and this would assist in choosing an appropriate method to approach the content.

Bukova-Gűzel (2010) developed a comprehensive framework and concluded that knowledge of the learner is:

1. having knowledge of learners' prior knowledge;
2. having knowledge of possible difficulties students may experience during learning;
3. having knowledge about of possible students' misconceptions; and
4. having knowledge about students' differences.

Looking at the view mentioned above, it would require a newly trained teacher coming from college to interact with learners a lot. The teacher who is new to the teaching profession might have subject matter knowledge but to acquire the

characteristics mentioned above he or she has to go into the classroom. To gain learners' prior knowledge the novice is advised to study the subject syllabus and curriculum in order to know what was done in preceding grades, the preceding topics to statistics and all knowledge the learners have which would make the topic understandable. Also, because the circuit in which the research was conducted is located in an area where learners come from different types of households with different languages it would be advisable that the novice teacher should know all these dynamics to be able to be effective in the classroom. Kanyongo, Scheiber and Brown (2007), after conducting studies on factors affecting learner performance in Mathematics in sub-Saharan Africa, found that students whose proficiency in the language of instruction was good, performed better than students whose proficiency in the language of teaching and learning was poor. Therefore, teachers should know how to choose a teaching strategy to address this problem.

2.4.3 Knowledge of instructional strategies

Estes, Mintz and Gunter (2011) discuss a number of instructional strategies ranging from cooperative learning, concept development to problem-centred inquiry that teachers employ in their classroom practice. The authors emphasise that teachers need to have knowledge of a variety of instructional models to be able to select the most potent strategy for a specific class or a specific topic. Ijeh (2012) explains that different types of teaching strategies, representations and activities are used in teaching mathematics. The author continues to say that knowledge of instructional strategies involves understanding ways representing specific concepts like models, illustrations, examples and analogies to facilitate learners' understanding. According to Shulman (1987), the use of examples and familiar contexts makes the topic accessible, meaningful and comprehensible to learners. However, the teachers continue to use direct instruction in the classroom as a predominant strategy despite having a variety of strategies at their disposal (Friedrichsen *et al*, 2009). Representations during teaching must have clear links and relationships between concepts and procedures must be comprehensible to the learner (Ibeawuchi, 2010). Van Driel, Verloop and De Vos (1998) argues that the majority of teachers do not have the ability to detect and identify difficulties of learners and their misconceptions and then teach conceptual change because most of them have not yet dealt with

alternative conceptions. It is due to the fact that they make use of very limited resources. For novice teachers, it may be difficult to choose appropriate methods for particular lessons, hence this study sought to explore how peer observation on the PCK of novice teachers in teaching Grade 11 statistics in a Circuit in Mpumalanga Province could enhance the teaching of statistics.

According to Carzola (2006), misconceptions and ways in which mathematics is taught, especially statistics leaves a lot to be desired. The author argues that the majority of statistics teachers do not have knowledge of the curriculum and the necessary ability of approaching the content. Shulman (1987) emphasizes that although the correct choice of an instructional strategy may be determined by the teacher's knowledge of the subject, the students' levels of understanding and characteristics are paramount. Sibuyi (2012) mentions three aspects that are important in mathematics lessons. These are:

(i) Cognitively challenging and well- structured learning opportunities;
(ii) Learning support through monitoring of the process and individual feedback; and
(iii) Adaptive instruction and efficient classroom and time management.

The knowledge of use of technology in statistics teaching is very vital in learner improvement in the topic because students are motivated (Duller, 2008; Chance, *et al*, 2006). The use of computer simulations and software packages is recommended. Teachers are encouraged to use these facilities in the instructional process to enhance teaching and learning. Although novice teachers were exposed to the use of technology during their time of training, the conditions in which they found themselves during the time of practice were not technology friendly. Software packages do not apply because of low socio-economic issues making schools not to afford computers for teaching instructions. The only laptop available in the school is used by administrators.

2.5 Studies carried out in the teaching of statistics

Garfield and Everson (2009) after a study on preparing effective teachers for statistics gave the following suggestions: teachers should know their subject matter at a deeper level and teachers should have good teaching skills. A similar study was

carried out on skills and strategies on competent teachers in statistics. Ijeh and Onwu (2013) mention that a study was carried out on four teachers in which interviews, observation, document analysis, application of questionnaire and conceptual knowledge exercise were carried out. The results indicated that competent teachers for mathematics used topic-specific skills and strategies in teaching statistics.

According to Sowey (2006), students are motivated to learn statistics when teachers show that statistics is useful, interesting and substantial. The author also focused on the art of asking questions in a statistics lesson and the following observations were made:

(i) Asking questions indicates student involvement in the learning process.
(ii) Students who are lost and confused do not know what questions to ask.
(iii) Student learning is enhanced when the teacher solicits challenging questions.
(iv) It is beneficial to ask challenging questions because they are searching questions which represent initial steps to independent thinking. Well-judged answers to the questions strengthen students' sense that statistics is important and they begin to ask researching questions in statistics.

Casey (2008) made a study on describing the subject matter for teaching statistical association at secondary school level. The study was carried out on three teachers in which lesson observation, interviews, analysis of students' work and records analysis were done. The study brought to light five knowledge bases on statistics:

(a) Knowing why data are needed and how they can be produced.
(b) Familiarity with descriptive statistics elementary terms and ideas.
(c) Awareness with basic terms and ideas about graphs and tables which display data.
(d) Understand basic probability.
(e) Knowledge of statistical conclusions.

These five knowledge bases are very important because they assist teachers to approach the topics on statistics in a methodical and practical way. Students will not just calculate using meaningless data, but they will understand how data has been collected and then manipulate and analyse it.

Burgess (2009), in a study on types of teacher knowledge in the classroom, explored teacher knowledge in teaching statistics through investigations. Four second year teachers were selected and the following categories of teacher knowledge for teaching were recommended:

(a) Common knowledge of content which refers to what any person would know and can do and it is not specific to the teacher. It is the ability to recognize wrong answers, spot inaccurate definitions in textbooks, use mathematical notation correctly and do work assigned.

(b) Specialized knowledge of content-which includes the ability to justify a choice of which measure is more appropriate for a given set of data or to explain these skills. The knowledge includes the ability to evaluate students' explanations around whether it is possible to generalize from the data at hand to a larger group and to reason with models.

(c) Knowledge of contents and students.

(d) Knowledge of content and teaching-which includes the ability to appropriately sequence the content for teaching, to recognize instructional advantages and disadvantages of particular knowledge and statistical representations.

Eichler (2008) made a report focused on a research project combining three aspects concerning teachers' planning, teachers' classroom practice and their statistical knowledge. The study was carried out on four teachers who were interviewed. The results obtained were the following: the teachers differed a lot in terms of main objectives of statistics instruction and there were remarkable differences between the students of the four teachers with respect to their interpretations and understanding of content. In principle, classroom practice should allow appropriate classroom procedures and descriptive feedback. The author also suggests that if all assessment techniques and strategies are employed, teaching and learning of statistics would be successful.

Shi, He and Tao, (2009) in a study carried out in China found that the development of statistics in that country is very slow considering that it is the second biggest economy in the world. The majority of people view statistics not as an independent discipline but as a part in mathematics. Shi *et al* (2009) argue that the discipline is taught and studied theoretically without exploiting data modelling which promotes

analytical thinking. Also worrisome is that teachers are not well prepared to teach statistics at high school level.

Ijeh (2012) conducted a case study in Gauteng Province in South Africa on how competent teachers develop PCK in statistics teaching. The study was carried out in Tshwane North District, Cluster 3 in Gauteng. Six teachers from 6 separate schools wrote a conceptual knowledge exercise [CKE] in statistics. Top 4 teachers were selected and were then involved in concept mapping, interviews, lesson observation and filling in of a questionnaire and document analyses were done. The lessons observed were video recorded. The results obtained showed that:

(i) The four participants taught statistical graphs using procedural knowledge.

(ii) The four teachers used topic-specific instructional strategy of providing exercises in statistics whereby learners were involved in problem solving while teachers' role was monitoring the activities which allowed the learners to construct their own knowledge.

(iii) A number of techniques were noted which comprised oral probing, extra lessons and class activities which facilitated the teachers to detect learners' misconceptions and learning difficulties.

(iv) The teachers developed knowledge of learners' learning difficulties by analysing their written work, assignments and oral discussions.

According to Wessels and Nieuwoudt (2011), a profiling questionnaire was applied to ninety teachers from grade 8 up to grade 12 of 23 schools from different socio-economic backgrounds in a city in South Africa. The objective of the survey was to try and establish mathematics teachers' beliefs and confidence to give information on the development of in-service education programmes for grade 8 and grade 9 teachers. The researchers found out that the teachers had great confidence in teaching statistics topics but showed low levels of statistics thinking.

2.6 Challenges faced in the teaching and learning of statistics

According to Tishkovskaya and Lancaster (2012) in a paper on reviews on recent literature related to the teaching and learning of statistics, teaching statistics has posed a lot of challenges because there is focus on mathematical and mechanical aspects of knowledge which result in learners not being empowered to apply

statistical content and knowledge to solve problems arising from a specific context. The aim of the paper was to help teachers and instructors improve the teaching and learning of statistics. The study brought to light the following challenges:

a) Learners had negative attitudes towards statistics and they lacked basic mathematical and statistical skills.
b) Learners were exposed to mechanical aspects of knowledge which did not allow them to apply statistics content to solve practical problems.
c) Learners showed that they had no background of statistics.
d) There was lack of graduate programs to train teachers to teach statistics.

However, in another study carried out by Batanero, Burrill and Reading (2011), it was found that teachers' attitudes and beliefs have a great impact on the teaching and learning of statistics in the classroom. The study brought to light the following:

(a) Teachers believed that they experienced more difficulties in statistics than in other mathematics topics.
(b) They considered themselves not well-prepared to help their learners face challenges in statistics.
(c) They believed there was not adequate programmes for professional development in the teaching of statistics and that they rarely use statistics to analyse educational data.

Estrada, Batanero and Lancaster (2011) echo similar sentiments to Batanero *et al* (2011) with the view that teacher training in statistics involves only cognitive aspects of teaching and very little attention is paid to the emotional aspects. The writers argue that the emotional component has a lot of influence because it may impede the teaching and learning of statistics. Positive attitudes of teachers would also promote positive attitudes of learners in statistics and negative attitudes in statistics in teachers would also instil negative attitudes in learners.

Makwakwa (2012) in a quantitative research aimed at exploring problems encountered in statistics and learning in Grade 11 carried out on 448 learners and 100 teachers in Gauteng Province of South Africa obtained the following results in summary:

(a) Teachers did not teach effectively the methods to draw statistical graphs.

(b) The concepts mean, mode, median, variance, standard deviation and quartiles were not defined well and the methods to obtain them were not explained well in grouped data.

The causes of the above-mentioned problems were outlined as follows:

(i) Teachers did not have comprehensive knowledge and strong content knowledge of statistics.

(ii) The teachers encountered difficulties to interpret learners' misconceptions because they lack content knowledge.

(iii) Teachers encountered problems because the information in the textbooks on statistics is vague. Certain important formulae were missing.

(iv) In-service training programmes (INSET) did not cover all topics of statistics.

(v) Teachers were not attending INSET programmes organized for them.

Opolot-Okurut, Opyene-Eluk and Mwanamoiza, (2008) in a study carried out in Uganda found out there was shortage of suitably qualified teachers for mathematics and statistics because teachers were leaving the teaching profession for greener pastures. Fewer teachers who remained were overloaded with a lot of work and were poorly remunerated. Also obtained in this study was the shortage of learning materials and resources like textbooks. Lack of familiarity with statistics content poses a challenge to teachers' ability to impart knowledge to learners in a way they would understand (ICMI/IASE, 2007).

Chick and Pierce (2008) in their study on PCK on primary school statistics argue that the degree to which statistics teaching focuses on rules or on critical thinking depends on the teachers' perceptions of and knowledge of statistics together with PCK. The study was carried out on 27 pre-service primary teachers who were made to complete questionnaires and plan lessons for Grade 6. The results obtained show that the plans focused on correct graphical representations and calculations using statistical figures with little emphasis on trying to make the data comprehensible. In the study, it was found out that primary school mathematics were deficient of statistical knowledge and PCK.

Jacobbe (2007) explored teachers' understanding of statistics teaching as they implemented new curricular materials which comprised ten lessons on statistics topics in each grade. These materials helped reveal how elementary teachers

understood statistics to implement standards prescribed by the GAISE document. The study revealed that the teachers were not prepared to teach statistics according to the prescribed standards. In a study conducted in three Australian states, 40 teachers were selected. According to Watson, Callingham and Nathan (2009), the teachers were involved in a learning project in statistics for the middle school. The teachers were teaching from grade 5 to Grade 12 and their professional experience ranged from 2 to 25 years. Interviews were conducted to explore teachers' PCK in statistics at middle school level. The results obtained showed that 9 of the teachers demonstrated high level of PCK in statistics, 14 showed medium degree of PCK and 17 were classified as low. This study has revealed that there was lack of PCK in statistics in the majority of teachers. Carzola (2006) argues that misconceptions and the strategies used to teach mathematics are among the factors that contribute to learners' difficulties in statistics.

Ben Zvi and Garfield (2007) argue that statistics is a challenging subject to teach because statistical ideas are complex and difficult to grasp. In their report, many learners lack basic mathematical skills in working with fractions, decimals, proportions and algebraic formulae, among others, which militate against the teaching and learning of statistics. Learners are misled by the context in which they learn statistics and they end up using their faulty intuition instead of selecting a statistical procedure and rely on data-based evidence (Ben Zvi and Garfield, 2007).

2.7 Research reporting on challenges faced by novice teachers

According to Melnick and Meister (2008), when novice teachers enter into classrooms for the first time, they face the challenge of seeing the reality of what is involved in teaching which might be different from their expectations. Murshidi, Konting, Elias and Fooi (2006) explain that novice teachers encounter the complexity of actual teaching practice and this becomes a reality shock to them. According to the authors, the novice teachers are discouraged from continuing because there are disparities between what they learnt from universities and colleges and the real world of teaching.

Various researchers (Amoroso, 2005; Cobbold, 2007; Howe, 2006 and Street, 2004) argue that the first year of teaching for a novice teacher is a year of struggle for

survival as he or she has to grapple with daily interactions with experienced colleagues, learners, the curriculum and many other aspects related to the teaching profession. The novice teachers have to cater for learners with diverse needs, effectively assess learners and deliver quality lessons using various teaching strategies at their disposal. Murshidi *et al* (2006) argue that training novice teachers to be effective and successful should not only be the responsibility of the teacher preparation programs, but other stakeholders must also participate. Flores (2004) emphasizes that teachers develop professionally, sociologically and psychologically in schools and that schools can be utilized as professional learning communities in which teachers can engage in collaborative learning and develop knowledge and skills.

Salleh and Tan (2013) in their study on novice teachers in Shanghai found out that beginning teachers often do not know what questions to ask and how to articulate the questions. Ong *et al* (2010) in a similar study on questioning techniques found out that novice teachers posed questions which did not open opportunities for students to learn mathematics in a meaningful and fruitful way. The questions did not convey implicit messages about the nature of mathematics nor engage students' intellect to make connections so that they will be able to develop coherent framework for mathematical ideas. They argue that the mathematical questions posed were closed factual questions while the mathematical task focused on memorization and procedures and that the novice teachers rarely asked higher cognitive questions and are impatient to wait for students to think before responding.

Zakaria and Adnan (2010), in a study on pre-service mathematics teachers, discovered that teachers' beliefs about mathematics have an impact on their practice of teaching. The authors explain that novice teachers have the perception that mathematics consists of facts, procedures and regulations that need to be memorized. Pre-service teachers are trained at colleges and when they start work they become novice teachers and they go into the classroom with their perceptions and beliefs.

According to Ham (2011), researchers have found that beginning teachers have a difficult time differentiating individual tasks. They choose certain tasks without understanding the learning process occurring throughout the lesson. The author

explains that novice teachers duplicate activities they did at college but have problems in devising their own tasks proving that they lack originality. The writer suggests that a way for beginning teachers to understand the development of worthwhile mathematical tasks is to observe experienced teachers and learn developing their own tasks.

Berry *et al* (2009), in a study carried out on four novice teachers who were assigned to teach in a high-poverty school to implement Principles of School Mathematics, found out that only one was judged to be proficient in all the principles. The other three fell short of interpreting the principles. This proves that novice teachers need support in their PCK development. The NCTM principles are:

1. Equity-excellence in mathematics evaluation requires equity-high expectation and strong support for all.
2. Curriculum-a curriculum is more than just a collection of activities: it must be coherent, focused on important mathematics and well-articulated across the grades.
3. Teaching-effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.
4. Learning-students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.
5. Assessment should support learning of important mathematics.

Looking at the five principles, it is clear that they form part of teacher PCK which according to the study, the greater part of novice teachers could not satisfy the requirements. According to the author, three common factors, which contribute to the growth of PCK in early career teachers are subject matter knowledge, classroom experience and possession of emotional attributes like self-confidence and provision of supportive working atmospheres in which collaboration is encouraged.

The bulk of literature seems to suggest that novice teachers are less effective than those with experience. However, some studies have shown some evidence that teacher effectiveness declines at some point among high school teachers. Evidence shows that teachers with more than 25 years of classroom experience are less effective than their inexperienced counterparts (Harris and Sass, 2008; Ladd, 2008).

These findings that, in some cases, experienced teachers may be less effective than their less experienced counterparts suggest novice teachers' work should not be undermined. It shows that experienced teachers also have a lot to learn from novice teachers because they bring new knowledge from universities and colleges which can be used in the teaching and learning of various subject areas. According to Makwakwa and Mogari (2012), many teachers never trained to teach statistics in schools. The content on statistics was introduced only in 2006 in the FET band. Newly trained teachers from universities and colleges bring in new knowledge into the teaching profession hence their contribution should not be undermined even though they may have less classroom experience.

2.8 Conclusion

This chapter reviewed aspects of PCK and the teaching and learning of statistics. It began with review of literature on peer observation of teaching and went on to review literature on problems encountered in the teaching and learning of statistics. The chapter ended up discussing the problems faced by novice teachers and problems they encounter in the teaching of statistics. The next chapter presents the research design and methodology.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

In this chapter, I describe the processes of data collection and analysis in order to answer research questions stated in Chapter 1. This chapter starts with the description of the research paradigm which was selected then followed by the research design and methodology used. The research questions are re-stated together with the aims and objectives of the study. This chapter continues to explain how the population and sample were selected. It goes on to give a picture of how POT was conducted and describes the research instruments which were used in the study. Issues like how the research instruments were administered are also explained.

3.2 Research paradigm

The study was conducted within an interpretive paradigm. According to Mack (2010) interpretive research is observed from inside through the direct experience of people. The author continues to state that the responsibility bestowed on the researcher would be to demystify and explain social reality through the eyes of different participants. Through this paradigm, I mingled with participants and got information from their different views about peer observation teaching. Interpretivism stresses on subjectivist approach to studying social phenomena and attaches importance to a range of research techniques focusing on qualitative analysis, for example personal interviews, participant observations, account of individuals and personal constructs (Mack, 2010). Personal interviews are face-to-face conversations between the researcher and participants in the study. In this study, I used them to gain insight into the opinions and views of the participants. Macmillan and Schumacher (2010) assert that participant observation is a technique of field research in which the researcher studies the life of a group of subjects intimately mingling with them and sharing with them in their activities. During this study, I mingled with the novice teachers in their teaching practice as a participant observer in each instance. Personal constructs are

personal views and opinions of people about the world around them. In this study, I sought to understand how novice teachers viewed the POT process as a tool for teacher development and enhancement of the teaching of statistics. Employing this paradigm helped the researcher make sense of the participants' beliefs, knowledge about teaching statistics and use of learners' thinking in the classroom. The paradigm was suitable for this study because it assisted me to find out the teachers' understanding of reflective practice and understand the actions the novice teachers took to improve their teaching skills in statistics.

3.3 Research aim and objectives

The aim of the study was to explore how peer observation of teaching on the PCK of novice teachers in teaching Grade 11 statistics in a circuit enhances the teaching of mathematics. This study therefore sought to:

- Determine the activities that favour peer observation of teaching for improving novice teachers' PCK in teaching Grade 11 statistics.
- Determine the nature of improvement on the novice teachers' PCK in teaching grade 11 statistics.
- Determine how peer observation of teaching of novice teachers improves the teaching of grade 11 statistics.

3.4 Research Questions

The main research question of the study was:
How does peer observation of teaching on the PCK of novice teachers in teaching Grade 11 statistics enhance the teaching of mathematics in a circuit?
In the study, the following sub-questions were answered:

d) What activities favoured peer observation of teaching for improving novice teachers' PCK in teaching Grade 11 statistics?
e) What was the nature of improvement on the novice teachers' PCK in teaching statistics?
f) How does peer observation of teaching of novice teachers improve the teaching of grade 11 statistics?

3.5 Research approach and design

In this section, I present the research design and approach followed in this study.

3.5.1 Research design

According to Awoniyi *et al* (2011: 45), research design is more or less a “blue print” or plan of research or it is like the plan of a house. In this research, a case study design was used. Creswell (2008:146) refers to a case study as “an in-depth exploration of a bounded system like an activity, event, process, or individual based on extensive data collection”. The case study design allowed me to concentrate on a specific instance or situation and attempt to identify the various interactive processes at work. In this case, I sought to explore how peer observation of teaching on the PCK of novice teachers in teaching Grade 11 statistics in a certain circuit enhances the teaching of statistics. Similar studies were also conducted by other researchers on teachers’ pedagogical content knowledge (Yusof and Zakaria, 2010; Bukova-Guzel, 2010; Chick, Pham and Baker, 2005 and Ijeh, 2012). Macmillan and Schumacher (2010) mention that in a case study data collection is extensive and varied depending on the type of situation.

Through the case study design, I explored novice teachers’ pedagogical skills, their strengths and weaknesses and their commitment to work as well as their knowledge of mathematical content and curriculum. The case study allowed me to gain insight into the type of PCK the novice teachers used in the classroom and identify the other aspects of PCK which need to be improved.

The case study design has been criticized by various researchers owing to its methodological shortcomings in generalizability and transferability of findings because of focusing on very few cases (Merriam, 2009; Rule and John, 2011). According to Merriam (2009), in spite of these pitfalls a sizeable number of researchers have continued to use the same design in PCK studies because it provides a detailed and concise description in natural settings.

According to Macmillan and Schumacher (2010), in a case study, data collection is extensive and varied depending on the type of situation. Through this case study, I hoped to determine and detect novice teachers’ pedagogical skills, their strengths

and weaknesses and their commitment to work as well as their knowledge of mathematical content and curriculum. The case study allowed me to gain insight into the type of PCK the novice teachers use in their mathematics classroom.

3.5.2 Research approach

For this study, I used the qualitative research approach which enabled him to understand and explore the richness, depth, context and complexity within which teachers on the research site operated. According to Domegan and Fleming (2007), qualitative research has an aim to explore and discover issues about the problem on hand because very little is known about the problem. Awoniyi, Aderanti and Tayo (2011) explain that qualitative research yields a lot of information and allows interaction with participants. Qualitative research attempts to study the everyday life of groups of people in their natural settings such as educational settings and processes (Denzin and Lincoln, 2011). According to William (2007), qualitative research is a holistic approach that is composed of the process of discovery and is a model that occurs in a natural setting enabling the researcher to develop a high level of detail because of high involvement in actual experiences. Various scholars argue that human learning is best studied using qualitative research methods (Domegan & Fleming, 2007; Henning, Van Rensburg and Smit, 2004; Denzin and Lincoln, 2011). This study was focused on an educational process therefore I had the opinion that qualitative research approach was appropriate. Similar studies were also carried out using qualitative research approach (Sibuyi, 2012 and Bukova-Guzel, 2010).

Macmillan and Schumacher (2010) state that interpretive and constructivist researchers use systematic procedures, rather than trying to be objective, while considering researchers' professional judgments, views and perspectives in the interpretation of data. Consequently, during this study, I had an in-depth understanding and interpretation of the subjective experiences of novice teachers and learners in a certain circuit of a district in Mpumalanga Province, South Africa. Research procedures and instruments were arranged prior to the start of the research study.

3.6 Research site and population

A circuit situated in a selected district in Mpumalanga Province of South Africa was the site of this study. The circuit consisted of ten secondary schools during the time this study was conducted. Two secondary schools were selected from the circuit. The afore-mentioned circuit was closer to my place of work hence it was convenient to use in order to minimise transport costs. Also, the site was selected based on the information from district office which indicated that the circuit had the largest number of mathematics novice teachers compared to other circuits in that district. The population of the study was five novice teachers of mathematics in that circuit in Mpumalanga Province of South Africa.

3.7 Sample of the study

The sampling technique which I used in the study was purposive sampling. Macmillan and Schumacher (2010) define purposive sampling as a sampling technique whereby the researcher selects subjects from the population that have certain characteristics. The researcher selects the subjects which are representative of the population. In this study, a sample of two mathematics novice teachers from two different schools in the circuit was selected. The two teachers came from the two nearest schools to the place of work of the researcher. The sample of two novice mathematics teachers, according to my view, was more representative of the population of five novice mathematics teachers in the circuit. In addition, such a design of selecting two teachers was also used by some researchers (Sibuyi, 2012; Randall, 2008) in their in-depth studies conducted to explain teachers' PCK development.

3.8 How peer observation of teaching process was conducted

The process of peer observation of teaching was conducted in the following manner:

Each novice teacher observed five lessons, that is, two lessons conducted by the researcher and the other three lessons conducted by the other novice teacher. In other words, the two participating novice teachers observed each other teaching three times. During classroom observations of the novice teachers, the researcher

observed the lessons in company of one of the novice teachers. Both novice teachers simultaneously observed me teaching twice. Peer observation of teaching initially took place in the researchers' school where both teachers came to observe the researcher teaching statistics in his grade 11 classroom. After two days, Teacher A was observed and after another two days, Teacher B was then observed teaching in schools A and B, respectively. Each teacher was observed two days after the previous teacher had been observed. I fetched and transported each of the novice teachers to the respective observation school sites where classroom observations were due to be conducted. The POT process took place for three consecutive weeks as per permission schedule arrangement sorted with their respective school managers. The distance between the schools of each of the novice teachers and my school was five kilometres.

The POT process was conducted using stages of the model proposed by Bell (2002):

1. Pre-observation meeting;
2. Observation;
3. Post-observation feedback; and
4. Reflection.

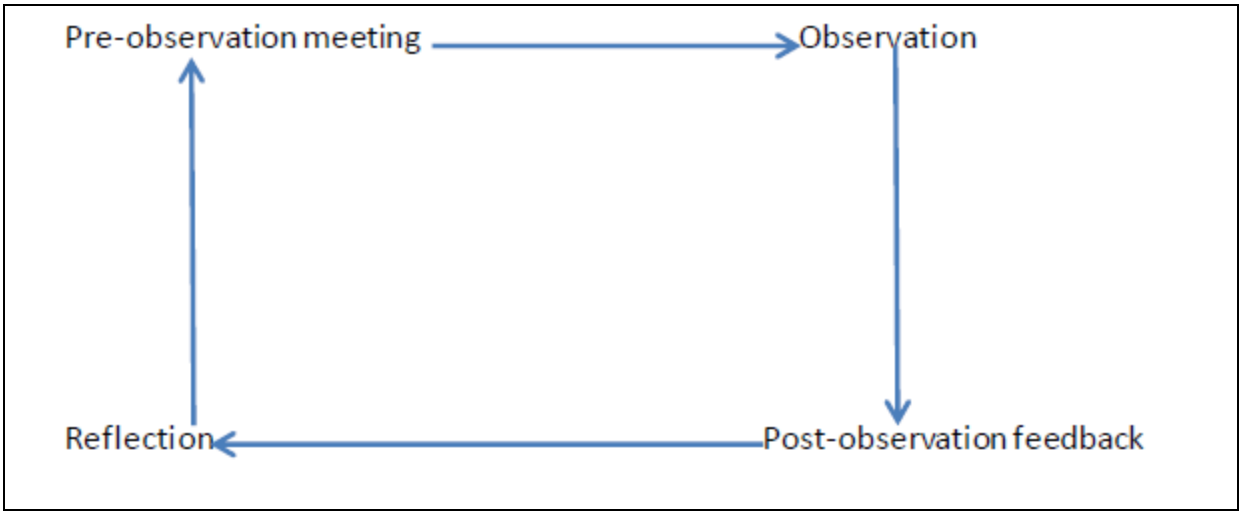


Figure 3.1: Peer observation process. Adapted from Bell (2002)

The pre-observation meeting was conducted before all the observation schedules to clarify expectations, logistics and protocol for the observation process. This was

followed by observation in which a classroom observation schedule was used. During observation, an atmosphere of mutual trust, respect and collegiality was established. Each classroom observation consisted of a pre-lesson semi-structured interview in which discussion was conducted about the goals, objectives, content, teacher-learner activities and instructional strategies. The pre-lesson semi-structured interview was followed by lesson observation in which observers for each lesson took field notes of what occurred in class especially teacher-learner interactions, the use of resources and the general classroom atmosphere. After each lesson, a post-lesson semi-structured interview was conducted to review the lesson. In the post-observation feedback meeting, there was review of the whole POT process focusing on the positive and negative aspects including suggestions for improvement in future POT activities. During reflection, each novice mathematics teacher indulged in self-examination on what adjustments to make after the peer observation process taking into consideration recommendations made by fellow peer observers.

The POT process started with a pre-observation meeting which was held at my school after prior arrangements were made with my principal and the respective principals. The two participants attended the meeting together with me in which information about the two participants was gathered and discussion about the logistics of the POT process was conducted. This was followed by preliminary observations which I conducted at each of the participants' school, consecutively. A set of observations on me by both participants together with those on participants by the observer followed.

The activities conducted in the POT are as follows:

1. Each novice teacher observed five lessons, that is, two lessons conducted by the researcher and the other three lessons conducted by another novice teacher.
2. Each novice teacher was observed by the researcher together with the other participating novice teacher three times teaching statistics.

After the classroom observations were conducted, a post-observation feedback meeting was conducted at my school which was attended by the two novice teachers and me. In this meeting, a review on the whole POT process was carried out with

participants voicing their views on the effectiveness of the process as a tool for teacher development. This arrangement concurred with the model presented by Bell (2002) and various researchers (Millis, 1992; Bovill, 2011; Robinson, 2010 and Semmound, 2015) who also assert that the POT process consists of pre-observation meeting, observation and post-observation meeting. Activities observed particularly during the POT process were classroom organisation, use of materials and teaching aids, teacher-learner interactions and use of instructional strategies, learner participation and assessment practice. This was done in tandem with recommendation by Bernstein *et al* (2000).

I also emphasised that the process was not judgmental and explained that it was meant for developing each other as teachers and for exploring the participants' PCK in the teaching of statistics in grade 11. The participants observed each other teaching and they also had the opportunity to observe me. These arrangements were in agreement with the findings of various researchers (Hendry *et al,* 2012; Eri, 2014 and Robinson, 2010) who argue that effective peer POT must be a reciprocal process in which colleagues observe each other's teaching practice with the objective of improving the quality of teaching.

I advised each novice teacher to introduce me and the other fellow novice teacher participating in the study to the class as visitors only and not engage in elaborated explanations. This was done to eliminate learner curiosity and fear of visitors during classroom lesson observations. This was in agreement with recommendations by Siddiqui, Jonas-Dwyer and Carr (2007) who gave tips for effective peer observation of teaching to avoid learner curiosity and fear of strange people who would visit their classrooms.

The activity of writing reports concurs with recommendations by Gosling (2000) who advocates that when POT is conducted, written reports should be produced. In each lesson observed, two critiques were written one by me and the other by the other observing participant. The two would meet and discuss to produce one comprehensive critique to hand over to each respective participant for studying and reflection. The feedback on the critiques was descriptive, candid and not judgmental.

Each participant was requested to ask questions about each critique for clarification to assist in the improvement of teaching skills in statistics.

3.9 Data collection instruments

In order to triangulate data semi-structured interviews, classroom observations and document analysis were used. Various studies were also conducted using observation schedule (Ijeh, 2012; Sibuyi, 2012 and Kilic, 2011). According to Cohen and Manion (1995), triangulation compares data obtained from different research techniques of data collection in the same study. Anderson (2000) argues that triangulation enhances reliability and validity. The following instruments were used in this study:

1. Pre-observation meeting with teachers (Appendix F);
2. Pre-lesson semi-structured interview schedule with teachers (Appendix H);
3. Lesson plan analysis tool (Appendix J);
4. Post-lesson semi-structured interview schedule with teachers (Appendix I);
5. Post-observation meeting with teachers (Appendix G); and
6. Classroom observation schedule (Appendix K).

3.9.1 Novice teacher profiling

Before the interviews and observations were conducted, the novice teachers were profiled. The two novice teachers were requested to provide me with details of their qualifications and years of teaching experience. Privacy and confidentiality was guaranteed with the use of pseudonyms. In this study, the two novice mathematics teachers were designated pseudonyms Teacher A [TA] and Teacher B [TB].

3.9.2 Semi-structured interviews

I conducted semi-structured interviews with each participating novice teacher. Each interview was conducted for forty minutes. The following semi-structured interviews were conducted:

1. The pre-observation meeting was done at the beginning of the data collection process. The aim of the interview was to obtain background information of

each novice teacher. The interview consisted of questions about the teachers' pedagogical beliefs of the participants and their experiences in their profession.

2. The pre-lesson semi-structured interview served as a pre-observation meeting between me and the novice teacher.
3. The post-lesson semi-structured interview sought clarification about what would have transpired in each novice teacher's classroom during observation.
4. The post-observation meeting was conducted at the end of the data collection process. The purpose of the interview was to get the views, perceptions and suggestions of the novice teachers about the effectiveness of peer observation as a tool for teacher development.

Various research studies (Ijeh, 2012; Ijeh and Onwu, 2013; Park and Chen, 2012; Rollnick *et al,* 2008) have been carried out using interviews. These interviews served to help researchers gain insight into the views and perceptions of teachers about the teaching and learning of some topics in mathematics. Creswell (2008) asserts that semi-structured interviews allow the researcher to get detailed responses from the participants. However, some researchers (Creswell, 2008; Macmillan and Schumacher, 2010) have criticized the use of interviews suggesting that participants may decide to furnish the researcher with false information.

During the interviews, I was able to interact with the participants on a one-on-one basis and probed on their responses by asking for clarification where necessary. Arrangements were made to carry out interviews with the novice teachers at times convenient to them. During data collection, the pre-lesson and post-lesson semi-structured interviews also helped me gain insight into how each teacher prepared each lesson, the teachers' beliefs, reasons why some events occurred in the classroom and some general knowledge about each teacher.

3.9.3 Classroom observation

In this study, I observed participants actively involved in teaching lessons in statistics in Grade11. Cohen *et al* (2000:305) mention that observations allow the gathering of "live data from live situations" and establish insight into the extent to which the teachers teach. According to Cohen *et al* (2011) and Opie (2004), there are

limitations on using classroom observations because they are time-consuming and prone to researcher bias. It is acknowledged here that collecting and analysing a large number of lesson videos was time-consuming, but allowed for a much more detailed description of the teacher's practice than other methods. Field notes were taken during or immediately after lessons and these captured my perceptions of the situation observed. To reduce researcher bias, transcripts of actual lessons were requested and the peer observers were further requested to provide more accurate accounts of the actual events and these were revisited on numerous occasions during the data analysis phase of the research (Opie, 2004).

The novice teachers were observed while actively involved in teaching and learning of lessons in statistics in Grade 11. The lessons were video recorded in order to be revisited during data analysis by both myself and each of the novice teachers. During each classroom observation, one of the observers, either myself or the other participating novice teacher, would conduct video recording. Before each lesson, the researcher engaged in a pre-lesson semi-structured interview with the teacher. After each lesson I conducted a post-observation semi-structured interview with each respective novice teacher to reflect on the highlights of the lesson.

3.9.4 Document analysis

Document analysis was conducted to obtain information as to whether each participant was adhering to curricular requirements postulated in the policy documents of the subject mathematics on how statistics should be taught. Learners' written work and teachers' lesson plans were examined inclusive of all documents used in the instructional process. Field notes were taken down from these documents. Critiques from curriculum advisors and heads of departments which were in the files of the participants were also analysed. From the teachers' portfolios the researcher also looked for information about the teachers' reflection about each lesson and how he or she intended to avert learners' learning difficulties and misconceptions. The purpose of document analysis was to assist in triangulating with data collected from interviews and classroom observation. The novice mathematics teachers were promised that their identities would never be disclosed and they would be free to withdraw from the study at any time.

3.10 Trustworthiness of the study

According to Sinkovic, Penz and Ghauri (2008), trustworthiness in qualitative research has the aim of supporting the notion and argument that the findings of a research or study are of great value and worthy of receiving attention. During the study the aspects such as credibility, dependability, confirmability and transferability were considered in order to establish trustworthiness. Credibility was ensured by physically observing the lessons conducted by the novice teachers. The lessons were also video-taped. This ensured that there would not be any fabrication of what really transpired during the study. Field notes were taken at the research sites and cross-checking was done with the novice teachers about what really transpired during the lessons observed. I conducted pre-lesson and post-lesson semi-structured interviews with the novice teachers for cross-checking. In order to establish dependability the study was carried out for a period of 3 weeks using different methods of data collection and different times on the same research problem. Confirmability was ensured by safely keeping the data collected which was used for interpretation. This would allow independent critical readers whom I engaged to evaluate the methods used to collect the data. To ensure transferability I could not make substantive generalisations. However I made thick descriptions about the research sites, population and sample to allow readers to decide whether the findings can apply to their situations, circumstances and contexts.

3.11 Ethical issues

After receiving permission from the Department of Basic Education, I visited schools of the two novice teachers and sought permission from their principals and consent of parents and learners to conduct the research. Learners received consent letters and took them to their parents and guardians for signing although they were not direct participants in this study. I met with each participant to sign consent forms and discuss modalities of the peer observation teaching process. The participants and I agreed that the observations would be conducted during normal school hours. The participants I also agreed that POT would be conducted during the period when learners would not be writing examinations. Data was collected in a period of three weeks. Each novice teacher was guaranteed privacy, anonymity and confidentiality. I

requested voluntary participation of the novice teachers in the study. Prior to conducting the study, I obtained an ethical clearance certificate from the University of South Africa.

3.12 Elimination of bias

In order to eliminate researcher bias in the study, each participant was observed by two people, me and the other novice teacher participating in the study. I encouraged each of the novice teachers to make honest critiques of all lessons observed. The identities of the two participating novice teachers were not disclosed to eliminate bias. Furthermore, the interview schedules did not contain leading questions.

3.13 Conclusion

In this chapter, the research paradigm, design and methodology were explained in detail. The research site, and sample, the data collection instruments and profiling of novice teachers were described in this chapter. Furthermore, details on the validity, reliability and ethical issues were explained. The next chapter presents research findings and data analysis.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

4.1 Introduction

The aim of this study was to explore how peer observation on the PCK of novice teachers in teaching Grade 11 statistics in a circuit enhances the teaching of mathematics. The previous chapter focused on the research paradigm, design and methodology used to collect data for this study and explained how it was done. This chapter focuses on the findings and analysis of data collected on the peer observation of teaching of the two mathematics novice teachers who participated in the study. Data was collected using classroom observation, semi-structured interviews and document analysis.

This was done to address the following main research question:

How does peer observation of teaching on the PCK of novice teachers in teaching Grade 11 statistics enhance the teaching of mathematics in a circuit?
In order to answer the main research question, the following sub-questions were asked:

g) What activities favoured peer observation of teaching for improving novice teachers' PCK in teaching Grade 11 statistics?
h) What was the nature of improvement on the novice teachers' PCK in teaching statistics?
i) How does peer observation of teaching of novice teachers improve the teaching of grade 11 statistics?

The semi-structured interviews covered how the novice teachers:

- planned and prepared lessons in the teaching of Grade 11 statistics;
- delivered the planned lessons in statistics; and
- felt about the effectiveness of the POT process in the teaching and learning of statistics.

4.2 Data analysis process

In the study, pseudonyms for the two novice teachers and I were used. Teacher A is referred as TA, Teacher B is referred as TB and the researcher is referred to as R. To analyse the data collected during the study, qualitative data analysis was applied.

According to McMillan and Schumacher (2010), qualitative data analysis comprises a process whereby data is analysed into categories, patterns and relationships identified. During the analysis process, data was synthesised and meaning was sought from the data collected. The process began with working with specific data and ended up with the creation of categories and patterns. In this study, data collected from semi-structured interviews, classroom observation and document analysis was manually transcribed. Field notes were also gathered during data collection, while transcripts of the semi-structured interviews, classroom observation and document analysis were examined, synthesised and critically analysed to identify themes and corresponding categories.

During the study, a two-step process approach adopted from Smith and Osborn (2003) was used to analyse data. Firstly, each transcript was read and studied several times. I used the left margin of each transcript to make notes. The notes made on the left margin of each transcript were used to summarise, paraphrase and analyse the data. Also, I analysed the similarities and differences of the transcribed data during the process. Secondly, I used the comments made on the left margin of each transcript to develop themes. Themes in qualitative research are patterns across data sets that are important to the description of a phenomenon and are associated to a specific research question (Braun and Clarke, 2006 and Clarke and Kitzinger, 2004). Some researchers (Shenton, 2004; Saldana, 2009 and Theron, 2015) suggest that qualitative data can be organised through the process of coding, a process in which data is broken up through analytical ways in order to produce questions about the data, providing temporary answers about relationships within and among the data. In this study, the data collected is discussed under the following themes:

1. The teaching of statistics by mathematics novice teachers;

2. Effectiveness of POT in the teaching of grade 11 statistics by novice teachers; and
3. Development and nature of improvement of PCK of mathematics novice teachers during the POT process.

Although the data collected was qualitative in nature, I felt that descriptions on data analysis can also be better illustrated by occasionally using statistical tables, reports and graphs. Hence some representations in this study were done graphically but all of them have explanations attached to them on each stage of the POT process.

4.3 Pre-observation meeting

A pre-observation meeting was conducted with both teachers at the researcher's school. This preliminary meeting allowed me and the two novice teachers to gain an understanding of how the POT was to be conducted. I pledged that he would transport Teacher A and Teacher B to wherever observation was to take place and bring them back to their respective schools throughout the duration of the study. The two novice teachers agreed with the researcher that observation would be conducted in the following manner:

(i) The two novice teachers would be observed on the same day, one teaching in early the morning and the other teacher would be observed before midday.

(ii) A preliminary observation would take place on each teacher before observing me.

(iii) The post-lesson discussions would be conducted a day after the classroom observations.

(iv) The POT process would be conducted over a period of three weeks.

(v) Observation on me would be conducted by Teacher A and Teacher B, observation on Teacher A would be done by Teacher B and I and observation on Teacher B would be conducted by Teacher A and me.

The duration of the meeting was one hour. During the meeting, I sought to know demographic information in the form of teachers' qualifications, age, experience in teaching mathematics, mathematics, grades taught and the current studies TA and TB embarked on at that time. In addition, I and the novice teachers agreed on the dates and times of the classroom observation sessions, that feedback would be both

written and oral and that the observers in each session would be expected to sit at the back of the classroom without actively participating in the lesson. The summary of this information is displayed in Table 4.1 below.

Table 4.1: Profiles of the two novice teachers

Item	Teacher A	Teacher B
1. Educational qualifications	BSc in Engineering and PGCE	BSc in Agricultural Engineering and PGCE
2. Age at the time of study	26	27
3. Gender	Male	Male
4. Experience at the time of study	4 months	I year 6 months
5. Grades taught since appointment	Grades 8, 10, 11 & 12	Grades 8, 10 & 11
6. Location of school	Rural	Rural
7. Name of school	School A	School B
8. Current studies	None	None

Table 4.1 above shows that the two participants had similar qualifications which were both degrees in engineering. The degrees in engineering have a strong mathematical content and this information gives the impression that the two teachers had strong mathematical backgrounds. The two participants had a difference of one year in terms of age which might imply that they had similar views on educational, social, economic and political issues since they attended universities at almost the same period. Also, the two participants grew up in the same rural area and were teaching in the same area when the study was done. This may suggest that the two participants were teaching groups of learners of similar backgrounds as themselves.

Teaching at two different schools sheds some light that the participants were exposed to two different organisational cultures and school management systems which had an impact on their classroom practices. In addition, the two participants had almost one-year difference in terms of teaching experience. This information suggests that the two teachers had differences in exposure to learners and to the

teaching environment. The difference in teaching experience may also suggest that the two teachers had different views of learners, instructional strategies, differences in interaction with experienced colleagues and approaches to mathematics and statistics content.

In the meeting in which demographic data was collected, I enquired about the teachers' assessment of the content the teachers learnt in their pre-service training with relevance to the teaching of statistics. The two novice teachers mentioned that they both studied some modules of statistics at university level. In an attempt to gain insight into the teachers' profiles, I posed the following questions:

R: *Apart from studying the content did you study any module(s) on the methodology on how to teach statistics at high school?*

The two novice teachers responded:

TA: *No I never studied any modules like that but I did modules in the teaching of mathematics in general when I studied my PGCE*

TB: *I never studied any methods of teaching statistics at PGCE.*

The two novice teachers acknowledged that they never studied any modules in the methodology in the teaching of statistics at their respective universities. This revelation implies that the two teachers did not have PCK to teach statistics even though they might have studied statistics content in their pre-service training.

R: *Are you confident and satisfied that the content you studied at college was enough to enable you to teach the statistics at high school level?*

The teachers' responses were:

TA: *Yes, I am confident and satisfied. Actually what we did at university was deeper than high school content and I believe I can tackle high school statistics.*

TB: *I am confident and the content which I studied can enable me to teach statistics content at high school level.*

The responses from Teacher A and Teacher B suggest that the two teachers were confident that they had adequate content knowledge to teach statistics because of

the modules studied at university level which had deeper statistical content than grade 11 statistics. Also, both teachers acknowledged that they both never taught statistics during teaching practice in their pre-service training. In the same meeting, Teacher A queried the support from mentors since he himself never got adequate support from his mentor during teaching practice. Teacher A made the following comment when I asked about his feelings about the contribution made by his mentor during teaching practice:

TA: *To be honest, I did not get enough support from the mentor. My mentor would always send me to teach in his absence. I observed only one lesson which my mentor delivered which we never held any discussion. I remember that he only visited me once for a few minutes.*

This information shows that Teacher A did not learn much from his mentor. On the contrary, Teacher B acknowledged the support he received from his mentor as satisfactory. Teacher A expressed that no one observed his lessons during teaching practice except the lecturers from the university who came to follow up and support him. However Teacher B applauded his mentor and experienced teachers who regularly observed his lessons.

I further probed:

R: *Do you think you got enough constructive criticism to enable you to improve your teaching from your mentors and lecturers?*

The responses from the two teachers differed:

TA: *My mentor never did much because he never really observed me teaching. My lecturers assisted me a lot and I believe that their recommendations have shaped my teaching and my beliefs.*

TB: *I believe my mentor who happened to be my HOD gave me enough support because we would always have post-lesson discussions. My lecturers did a good job. The unfortunate part is that all these interventions were not done in statistics, but I believe I developed skills in classroom management.*

Teacher A revealed the absence of adequate support from his mentor during pre-service training. He attributed the good skills in his teaching practice to the support

he received from his lecturer who made constructive criticism vital for his pedagogical development. On the contrary, Teacher B confirmed that his mentor was very instrumental in his development as a mathematics teacher because the mentor always availed himself at all times to support him in the form of (i) post-lesson discussions, and (ii) development of skills in classroom management. For Teacher B, the lessons observed were not in statistics.

I went on to probe:

R: *How long have you been teaching and have you ever taught statistics in grade 11?*

The two novice teachers responded:

TA: *I have 4 months of experience in teaching mathematics. This year will be my first time to teach statistics.*

TB: *I now have 1 year and 6 months of mathematics teaching experience. I taught grade 11 statistics last year and this will be my second year to teach the same content.*

The two novice teachers had different years of classroom experience and backgrounds in teaching statistics. When asked about how many workshops in mathematics each teacher attended, Teacher A stated that he attended only one content workshop organised by curriculum advisors. He lamented that the workshop he attended never covered the content on statistics. However, Teacher B mentioned that he attended three content workshops conducted by curriculum advisors, but no statistics content was covered. When they were asked about what they thought schools should do to improve the performance of learners in grade 11 statistics the two novice teachers expressed that many workshops in statistics teaching should be conducted to empower teachers. Teacher B went to express that universities should introduce modules in the methodology of teaching statistics to empower pre-service teachers in the content.

During the pre-observation meeting, I gave the novice teachers exemplars of prepared lesson plans to use. After perusal of the lesson plans, each one of the

teachers raised some concerns. The following are some of the questions they asked together with the researcher's responses respectively:

TA: *How did you predict that learners would face a particular difficulty in class?*

R: *Learners' anticipated learning difficulties are obtained from the teachers' knowledge of the characteristics of his or her individual learners. For example, I have been teaching the learners before. When I sit down to prepare for the lesson, there is need to think about whether a particular learner would understand based on the previous performance of that learner. In class, I should be prepared to tackle that problem in the lesson if it surfaces. It should not come up as a surprise. Also, when I read policy documents and diagnostic reports from the Department of Basic Education, I also get information about common errors committed by learners in examinations.*

Teacher B then requested for the Department of Basic Education website to download relevant documents. I provided the details and also referred the teachers to curriculum advisors at the district offices. This was a form of induction for both teachers which was never provided to them since there were no other mathematics teachers or mentors to help them in their schools ever since they joined the institutions

4.4 Classroom observations on the novice teachers and the researcher

Classroom observations were conducted during the study to gain insight into the teaching of statistics by the two novice teachers and their views about each other's teaching practice and my teaching practice. The observation schedule was arranged such that teachers' content knowledge, knowledge of instructional strategies, knowledge of learners' misconceptions and learning difficulties and general classroom environment and pedagogical issues were determined. In this section, some of the data is presented in tables and graphs as percentages. The percentages presented reflect how much of the time in each lesson was dedicated to any particular item. To understand the tables and graphs presented in this section it is important to explain the following:

For Teacher A

- Table 4.2, Table 4.6 and Table 4.10 illustrate the amount of time, in percentages, spent by the teacher using procedural and conceptual knowledge during Lesson 1, Lesson 2 and Lesson 3 respectively.
- Table 4.3, Table 4.7 and Table 4.11 illustrate the amount of time, in percentages, spent by the teacher using each instructional strategy during Lesson 1, Lesson 2 and Lesson 3 respectively.

For Teacher B

- Table 4.4, Table 4.8 and Table 4.12 illustrate the amount of time, in percentages, spent by the teacher using procedural and conceptual knowledge during Lesson 1, Lesson 2 and Lesson 3 respectively.
- Table 4.5, Table 4.9 and Table 4.13 illustrate the amount of time, in percentages, spent by the teacher using each instructional strategy during Lesson 1, Lesson 2 and Lesson 3 respectively.

4.4.1 Preliminary classroom observations on Teacher A

In this section, I present preliminary observations conducted on both novice teachers at their respective schools before they observed me. This was done to gain insight on their teaching styles, instructional strategies, content knowledge, use of resources and general classroom management techniques the teachers used before the POT process. The novice teachers prepared lesson plans independently without my involvement and other teachers. The classroom observations were conducted on the same day. The first to be observed was Teacher A in the morning and Teacher B just before midday. Post-lesson semi-structured interviews were conducted the following day.

4.4.1.1 Results of preliminary classroom observation on Teacher A

In this session, the observers were Teacher B and me. The following are findings of the pre-lesson semi-structured interview conducted on Teacher A.

R: *What do you intend to achieve in the lesson that I will observe?*

Teacher A's response was:

TA: *Learners to be able to determine measures of central tendency and dispersion*

The objective of the lesson was well stated. When I asked about learners' prior knowledge Teacher A, mentioned that he believed learners knew how to calculate mean, median, quartiles and drawing box and whisker diagram. Teacher A went on to outline the instructional strategies for the lesson as oral probing questioning, example and demonstration. He explained that he believed that his learners would participate in class and understand his explanations.

I further probed:

R: *What key concepts are going to be learnt in the lesson?*

Teacher A responded:

TA: *The key concepts are mean, mode, median, quartiles and box and whisker diagrams.*

Teacher A could outline the main concepts of the lesson. Teacher A mentioned that for the concepts to be understood better real life examples would be used in the lesson.

I went on to probe:

R: Do you anticipate any learners' misconceptions and difficulties in the lesson?

Teacher A responded:

TA: *Yes, I foresee learners having problems on quartiles.*

Teacher B also asked the following follow-up question:

TB: *What makes you foresee that the learners will face challenges on quartiles?*

On answering this question, Teacher A argued that he knew his learners had that problem in grade 10 so the problem would still haunt some of the learners. In order to solve the anticipated learners learning difficulties, Teacher A said he would go round looking for the learners with problems and assist them individually.

4.4.1.2 Description of preliminary classroom observation on Teacher A

Topic: Revision-Grade 10 Statistics	**Discussions on classroom activities**
Condition of classroom: There were 50 learners seated in rows and in pairs. Each learner was given a hand-out and each one brought his textbook. The teacher had a full view of all learners. Chalkboard and duster were available. There were no charts. The classroom was clean and there was discipline and order. -Teacher A was very nervous throughout the lesson.	-The classroom was conducive for learning. -The number of learners was manageable.
Line 1: The teacher wrote a question for learners on the board as per lesson plan. He asked: TA: *How do we calculate the mean?* A learner went to the board to get the mean and the answer was correct. All learners understood the procedure.	-The teacher used *procedural knowledge and content knowledge*. He explained the concept of 'mean' to the learners.
Line 2: The content was based on shoes. TA: *How do we get the mode?* A learner responded, "*We look for the number with the highest frequency*." Line 3 The teacher asked: TA: *What is the mode in this case?*" All learners responded by choosing the correct mode.	-The teacher used an example as an *instructional strategy.* -Line 3: The learners responded in chorus answer not giving individual learners chance to explain what they thought.
Line 4: Teacher A requested 4 learners to go to the board to determine the median. The learners presented their solutions on the board. The shoe sizes were **5; 4; 3; 6** and **4**. Three learners came up with answer 3. Only one learner arranged the shoe sizes in ascending order first and then identified size. 4 as the median size. The teacher said the one who first arranged the shoe sizes was correct.	-The teacher involved the class by calling some of the learners to present their responses on the chalkboard.
Line 5: The teacher wrote the data in order: **3; 4; 4;**	-The teacher used *content*

5; 6. Size 4 was identified as the median. The teacher calculated the lower quartile on the board. He explained: TA: *We have to look for the median of the left hand side.* He added 3 and 4 and got 7. Then he divided by 2 to get 3.5.	*knowledge* to deliver this part of the content. Also, he used *procedural knowledge.*
Line 6: The teacher explained how to write the five-number summary. He wrote the five-number summary on the board.	-The teacher at this stage was doing the work on the board without asking opinions of learners.

During the post-lesson semi-structured interview, Teacher A was asked if the lesson proceeded in the way he had planned.

Teacher A responded:

TA: *The lesson did not proceed the way I wanted because I gave an example with only 5 items of data. I realised that learners could not easily get the median on data with an even frequency. I was supposed to give another example with 6 or 8 items of data. This was going to avoid confusion in the classwork.*

Teacher A felt that the learners did not master the key concepts very well. He expressed that his learners understood how to determine mean and mode. Problems surfaced when it came to median and quartiles. The teacher also revealed that he detected that learners had difficulties in understanding quartiles. He stated that he tried his best to explain to the learners the procedure to determine quartile but he realised that he needed to conduct extra tuition.

I probed:

R: *Do you think your strategies were effective in the lesson?*

Teacher A's response was:

TA: *The strategies were not very effective. I did not ask learners many oral questions to allow them to think. I ended up using more of the lecture method.*

Teacher A expressed that he felt confident because he prepared for the lesson thoroughly and studied the content in depth from various sources. However he admitted he started to panic when learners showed that they did not understand how to determine quartiles. Teacher A asserted that the best way to overcome the problem of the misunderstanding of learners was to conduct extra tuition using examples of data with even frequencies.

I went on to probe:

R: *What did you learn about student learning from this class?*

Teacher A's response was:

TA: *I learnt that learners are not the same and understand concepts differently. Some learners take time to understand therefore the teacher has to be patient to assist those learners in order to achieve success.*

When asked what targets for improvement Teacher A set himself for his class, the teacher expressed that his target was to use thought provoking questions to engage learners. This strategy would allow learners to reason critically.

I further probed:

R: *If you were to teach this lesson again tomorrow, what would you do differently, and why?*

Teacher A responded:

TA: *I will give few more examples to facilitate learner understanding and make learners provide answers instead of me doing everything. I would also improve in asking questions to allow class discussion.*

The answers given by Teacher A during the post-lesson semi-structured interview indicate that he was engaging in reflective teaching. Teacher A was willing to improve the quality of his teaching given another opportunity to do so.

4.4.1.3 Discussion of findings of preliminary observation on Teacher A

The classroom environment was suitable for teaching and learning since adequate resources were available and the classroom was neatly arranged. Teacher A was visibly nervous and his eyes were continually glued on the observers. During the lesson, Teacher A demonstrated knowledge of relevant content knowledge. He showed he knew how to determine mean, mode and median. The following table shows how Teacher A made use of procedural and conceptual knowledge during the preliminary lesson.

Table 4.2 Manifestation of Teacher A's procedural and conceptual knowledge: preliminary lesson

Type of knowledge demonstrated by teacher	**Percentage manifestation**
Procedural knowledge	80%
Conceptual knowledge	20%

Teacher A used more of procedural knowledge to deliver this lesson. The teacher explained the procedures to determine mode, mean, median and quartiles, but did not explain their conceptual meanings. The following table illustrates how instructional strategies manifested in Teacher A's preliminary lesson.

Table 4.3: Manifestation of instructional strategies in Teacher A: Preliminary lesson

Instructional strategy	**Percentage manifestation**
Lecture method	80%
Oral probing questioning	10%
Discussion	5%
Group work	0%
Individualised instruction	0%
Demonstration	5%
Other	0%

Figure 4.1 illustrates how each instructional strategy manifested itself in Teacher A's preliminary lesson.

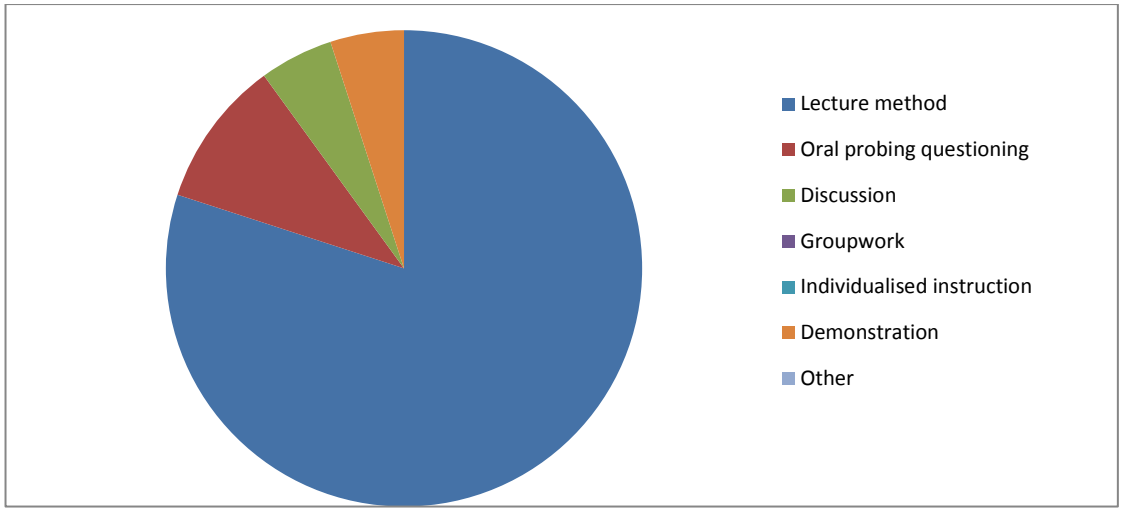


Figure 4.1: Manifestation of instructional strategies: Preliminary lesson of Teacher A

Figure 4.1 above reflects that during the preliminary lesson, Teacher A did little to involve learners owing to the predominant use of the lecture method in lesson delivery.

However, there are some issues Teacher B and I agreed upon after the observation of Teacher A's preliminary lesson. These included:

- The chorus responses by learners during the lesson did not give learners an opportunity to think critically and analytically.
- The teacher's failure to identify learners' misconceptions and learners' learning difficulties. Teacher A did not ask thought provoking questions during the lesson which would allow learners to participate effectively. The teacher sent learners to the chalkboard to write their solutions but did not give them the opportunity to explain their methods of solution to the class.
- Teacher A's use of examples was inadequate in explaining the concept 'median'. The teacher used an example with a data set of an odd frequency only. Learners understood this example very well. However, when the learners were required to determine quartiles they faced a challenge of having to calculate the medians of data sets with even frequencies. Teacher A was supposed to explain how to determine the median on data sets with both odd and even frequencies.

- Teacher A was supposed to explain the concepts well and then embark on a step by step explanation on how to determine the quartiles. During the lesson, he just dictated the procedure of determining quartiles.

Teacher B and the researcher expressed satisfaction about Teacher A's content knowledge and went on to encourage him to continue to study and consult the CAPS document on how concepts should be tackled in class. Teacher A expressed that he was grateful to receive constructive comments from me and Teacher A.

4.4.2 Preliminary classroom observation on Teacher B

Teacher B was observed by Teacher A and me teaching statistics in his school three hours after Teacher A was observed. During pre-lesson discussions with me and Teacher A, he clearly stated the objective of his lesson. When asked about learners' prior knowledge Teacher B stated he *expected learners to know how to find mode, mean, median and quartiles as well as drawing box and whisker diagrams.*

I went on to probe:

R: *What teaching strategies are you going to use in the lesson? May you explain why you choose these?*

TA: *Real life examples are going to be worked out on the board. This will make learners understand the importance of the topic.*

Teacher B went on to identify the key concepts of the lesson as the mean, median, mode, quartiles and draw box and whisker diagram. The teacher went on to mention that he would use real life examples during the lesson to foster conceptual understanding of the learners.

I further probed:

R: *Do you anticipate any learners' misconceptions and difficulties in the lesson?*

The response of Teacher B was:

TB*: Yes I expect some of the learners to experience challenges especially on median and the quartiles.*

When asked how he was going to assist learners with misconceptions and difficulties in the lesson, Teacher B responded:

TB: *I will visit the learners individually to check how many would be confused. If they are too many, I would need to repeat the explanation on the chalkboard. When I see that there are few learners who don't know what to do next I explain to them individually.*

From the discussion held during the pre-lesson semi-structured interview, it can be implied that Teacher B had prepared for the lesson thoroughly.

4.4.2.1 Description of the preliminary classroom observation on Teacher B

Topic: Revision of Grade 10 statistics	**Discussion on classroom activities**
Line 1: In the class there were 51 learners each one having a textbook, workbook and hand-out. The classroom was neatly arranged and all learners could see the teacher and the board.	-The classroom was a suitable learning environment.
Line 2a): The teacher introduced the lesson by asking learners if they still remembered Grade 10 statistics. The teacher asked: TB: *What things in Grade 10 statistics do you remember?* Learners answered in chorus: *"median, mean and mode"* Line 2b): The teacher gave the learners the following exercise. Determine mode, mean, median, quartiles and five-number summary of the following marks in:	-The teacher started asking learners about what they still remembered. He wanted to establish what they could still remember. -The learners answered in chorus not giving other learners opportunity of exercising their thinking. -Teacher B tried to engage learners to remember on their own what they did in Grade 10. He identified learner problems just as anticipated in preparing for the lesson. -The teacher could also detect learner

a) English: 75; 41; 35; 40; 60. b) Geography: 56; 60; 49; 34; 32 and 61.	misconceptions about the determination of the median.
-The teacher called two learners to the board one to answer question a) and the other to answer question b). The learners presented their work on the board. -The teacher said the learners were wrong in their calculations on median -He explained, "*For median, we first arrange our data in ascending order then we find the number in the middle."* -The teacher arranged for question a) and all learners were quick to realize the median was 48. For question b) a learner went to the board to arrange: 32; 34; 49; 56; 60; 61. The learner wrote median= 49 and 56. The Teacher explained that median= (49+56)÷2=105÷2=52.5	
Line 3: The teacher explained how to get the quartiles by saying, "*To get lower quartile you find the median of the left hand side of the median. The upper quartile you find the median of the right hand side of median.*" The learners were given classwork to do after this explanation.	
Line 4): In the classwork, no learner could find the quartiles. The rest were confused. The teacher had to do the exercise on the board. The teacher did	-The teacher identified learner errors in the classwork given.

the work correctly on the board. Learner participation was less.	
Line 5): The bell rang while the teacher was still explaining on the board. The teacher requested all the learners who had problems to see him at spare time.	-The teacher failed to manage time. Learners left the lesson not having understood fully how to determine the quartiles.
Line 6): The teacher forgot to give learners the homework as prescribed in the lesson plan.	-The teacher should have given learners some homework or extra work for practice.

After the lesson in the post-lesson semi-structured interview Teacher B was asked if the lesson proceeded in the way you had planned. He responded saying:

TB: *The lesson did not proceed the way I had planned because I failed to manage my time well. I ended up not giving learners some homework. Some of the learners did not understand how to get the quartiles.*

I probed:

R: *Did the learners master the key concepts of the lesson? Explain.*

Teacher B's response was:

TB: *I observed that the learners mastered the key concepts although there were some few learners who faced challenges. I say so because the majority of the learners could solve the exercises on their own.*

Teacher B expressed that detected that some of the learners did not understand how to find quartiles. He also asserted that his strategies were not effective because he ended up using the lecture method which limited learners' participation. Teacher B stated that he felt confident during the lesson despite some instances in which he struggled to explain to the learners effectively.

I went on to probe:

R: *Do you think your students learnt all that you wanted them to learn in this session? What brings you to this conclusion?*

Teacher B responded:

TB: *I do not believe so because the majority of the learners struggled in determining quartiles.*

When asked about what he learnt about student learning from this class, Teacher B responded:

TB: *I learnt that a teacher should not undermine the abilities of learners. I had some few learners who could calculate quartiles accurately with speed. Some learners can do things you may not have envisaged before. I also learnt that differentiation would be best considering the diverse needs of learners.*

Teacher B mentioned that his targets for improvement would be to make the least performing learner to be able to solve exercises without teacher assistance.

I went on to probe:

R: *If you were to teach this lesson again tomorrow, what would you do differently, and why?*

Teacher B's response on this question was:

TB: *I would adjust my time, use learner-centred strategies such as oral probing and give more examples on how to determine quartiles to enable full learner participation.*

The findings show that Teacher B was willing to improve his teaching by using learner-centred instructional strategies. Teacher B was engaging in reflective teaching.

4.5.2. 2. Discussion of Teacher B's preliminary classroom observation

The classroom was neatly arranged and the learners were all seated in positions in which they had full view of their teacher and the chalkboard. The environment was conducive for learning and teaching. Teacher B was visibly nervous. He confessed during the post-lesson semi-structured interview that he lost confidence at the beginning of the lesson, but later on gained some courage. At the beginning of the lesson, Teacher B introduced me and the other participating novice teacher to his

class. Table 4.2 illustrates how Teacher B used procedural and conceptual knowledge during the lesson.

Table 4.4 Manifestation of Teacher B's procedural and conceptual knowledge: Preliminary Lesson

Type of knowledge demonstrated by teacher	**Percentage manifestation**
Procedural knowledge	85%
Conceptual knowledge	15%

According to Table 4.4 above, Teacher B used more of procedural knowledge to explain the content. Teacher B explained expertly to learners how to determine mean, mode and quartiles. The teacher did not explain well the meanings of the concepts mean, mode, and quartiles. Table 4.5 below illustrates how Teacher B used instructional strategies during this lesson.

Table 4.5: Manifestation of instructional strategies in Teacher B: Preliminary lesson

Instructional strategy	**Percentage manifestation**
Lecture method	90%
Oral probing questioning	5%
Discussion	2%
Group work	0%
Individualised instruction	0%
Demonstration	3%
Other	0%

Figure 4.2 below graphically explains how the instructional strategies were used during the lesson.

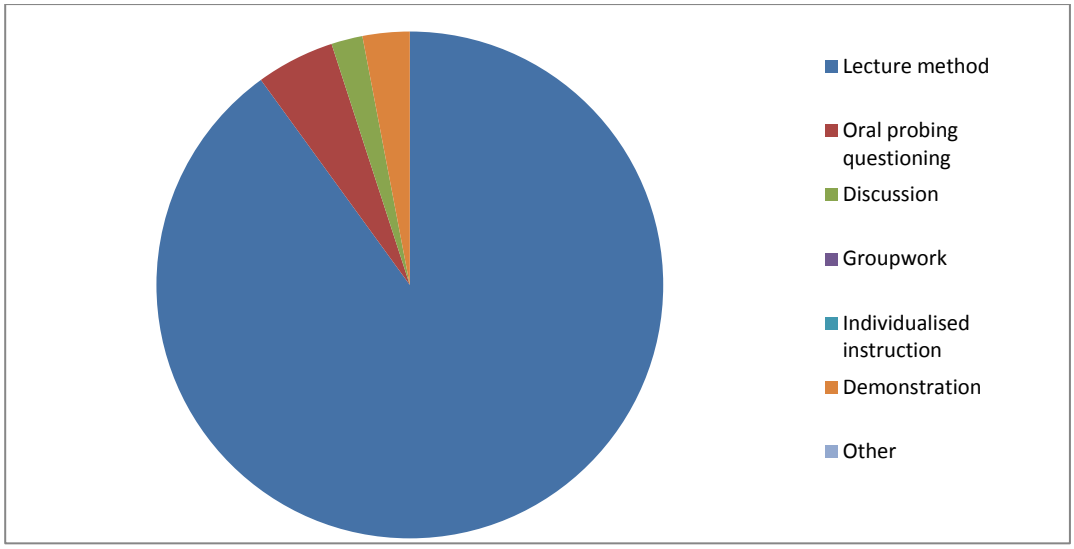


Figure 4.2: Manifestation of Teacher B's instructional strategies during preliminary lesson

During the lesson Teacher B demonstrated that he had dominion over his content. He did not commit conceptual errors in explaining the content to the learners. Teacher A and the researcher commended Teacher B for using adequate two examples to explain how to get the median and quartiles. The examples were adequate because the first one had an odd frequency and the other example had an even frequency. The learners were quick to understand the procedure of determining the median and quartiles of any data set.

However, I and Teacher A raised the following issues on the lesson presented:

- Learners responded in chorus answers which limited their critical and analytic thinking.
- Teacher B only used procedural knowledge to explain content on mean, median and mode instead of fostering conceptual understanding as well. The teacher did not explain the meaning of the terms 'lower quartile and upper quartile'.
- Teacher B could not identify some of the learners who committed some errors. It was evident that teacher lacked knowledge of learners' misconceptions and learners' learning difficulties.

During the discussion, Teacher B expressed that if he were to teach the same lesson again, he would explain the concepts median and quartiles. On quartiles, he would do step by step explanation on how to get them instead of reciting the procedure. This demonstrates that Teacher B was reflecting on how his lesson transpired. Teacher A was impressed by the two examples Teacher B used in his lesson and commented:

TA: *Given the opportunity to teach quartiles and median again, I would use similar examples just like what my colleague Teacher B did. I honestly have learnt something from my colleague.*

Teacher B could have performed better in class because he had already observed Teacher A and identified some strategies that suited his own presentation in his classroom. At this stage, a relationship of sharing ideas and examples to use when teaching the statistics topics was building.

4.4.3 Classroom observation on the researcher: Lesson 1

This section describes the first classroom observation conducted on the researcher by Teacher A and Teacher B. This was conducted two days after the post-lesson semi-structured interviews on both novice teachers' first lessons. The two novice teachers were invited to my school to observe him teaching on median and quartiles. The mathematics novice recorded data and the data was transcribed from the lesson plan, semi-structured interviews and classroom observations conducted on the researcher.

Before I delivered his first lesson, pre-lesson semi-structured interviews were conducted with the participants. The participants were encouraged to ask as many questions as they could in order to understand how and why the lesson was planned that way. In response to some of those questions, the researcher furnished them with all policy documents, diagnostic reports, learners' workbooks, annual teaching plan and the lesson plan. During the post-lesson interview, the two teachers expressed that they were impressed by the following features in the researcher's lesson plan:

I. The lesson plan was detailed.

II. The objective was stated including instructional strategies, resources, assessment strategies, learners' anticipated prior knowledge and difficulties, activities and reflection.

Summary and discussion on my first classroom observation

Topic: Revision on Grade 10 statistics	**Discussion on classroom activities**
Line 1: The learners were seated in positions in which they could see the teacher and the chalkboard. The number of learners was 62. The furniture was neatly arranged. Each learner was in possession of worksheets, calculator and textbook.	The classroom environment was conducive for teaching and learning.
Line 2: I introduced Teacher A and Teacher B to the class.	I did this to dispel anxiety and curiosity among learners.
Line 3: I used a variety of real life examples to teach mean, mode, median and quartiles. A variety of strategies were used in class such as group work, oral probing questions, example and demonstration.	I demonstrated knowledge of instructional strategies.
Line 4: During the lesson, the teacher did not allow chorus answers and each learner was supposed to raise hands to get an opportunity to explain his or her ideas.	This allowed learners to think critically and analytically.
Line 5: I marked the learners' workbooks highlighting their errors. The teacher addressed all the challenges the learners faced during the lesson.	I demonstrated knowledge of instructional strategies.
Line 6: During the lesson, I explained the conceptual meanings of mode, mean, median and quartiles. Furthermore, the	I showed both procedural and conceptual knowledge.

teacher showed the learners how to determine these quantities.	

After the lesson observation process, Teacher A and B were both overwhelmed on how I managed full participation and involvement of learners in the whole lesson. From the comments in the discussions held between the two novice teachers and me, the following points came out:

- Confidence is a powerful asset in lesson presentation.
- There is need to have courage to appreciate each other's work and emulate good teaching practice from others.
- Learner participation is an important asset in the teaching and learning of statistics.
- Chorus answers hamper learners' critical and analytical thinking.
- The teacher should foster both procedural and conceptual understanding in learners to allow effective learning to take place.
- Real life examples facilitate learners' understanding.

4.4.4 Second classroom observations on the novice teachers

After observing my first lesson, the novice teachers and I agreed on collaborative lesson planning so that the teachers could learn how to prepare lesson plans. This activity of lesson planning was conducted at my school a day before each lesson was delivered.

4.4.4.1 Summary and discussion of second classroom observation: Teacher A

During the pre-lesson semi-structured interview Teacher A mentioned that he intended to learners to be able to construct histograms. The teacher went on to state that he anticipated learners' prior knowledge to be in the construction of bar graphs and use of scale.

I probed:

R: *What teaching strategies are you going to use in the lesson? May you explain why you choose these?*

Teacher A responded:

TA: *I would use oral probing questioning, demonstration and example.*

Teacher A identified the key concepts to be learnt in the lesson as the concept of scale and histogram. The teacher went on to state that the use of real life examples would be dominant during his lesson to make the content to be meaningful to the learners. Teacher A anticipated learners to manifest difficulties in differentiating a bar graph and a histogram. To alleviate the learning difficulties Teacher A mentioned the use of individualised instruction and extra tuition to learners. After delivering the lesson the post-lesson semi-structured interview Teacher A asserted that the lesson did not proceed in the way he had planned. He expressed that he wanted the learners to understand how to construct the histogram but the majority did not understand the idea of scale.

I probed:

R: *Did the learners master the key concepts of the lesson? Explain.*

Teacher A's response was:

TA: *Learners understood the difference between histogram and bar graph but had problems in working with scale.*

Teacher A expressed that he detected that some learners did not understand how to work with scale in constructing histograms. The teacher felt that his instructional strategies were not effective during the lesson. He expressed that some of the learners did not understand well how to work with scale.

I went on to probe:

R: *During the lesson, did you feel confident and enthusiastic? Why?*

Teacher A responded:

TA: *I was confident because I had studied the content in depth.*

During the discussion Teacher A expressed that more than half the learners the understood the lesson while others showed that they had difficulties in understanding. When asked did what he learnt about student learning from this class, Teacher A responded:

TA: *I learnt that a lot of my learners need individual attention to be able to grasp concepts.*

I went on to probe:

R: *What targets for improvement have you set yourself for this class, and are they realistic?*

Teacher A responded:

TA: *I want learners of less cognitive abilities to understand and be able to do work on their own.*

Teacher A expressed that if given another opportunity to teach this lesson again in future he would dedicate more time explaining more about scale and how to use it in exercises. Teacher A was able to evaluate and reflect upon his teaching practice.

The summary of activities that took place in the lesson are summarised in the following section as well as manifestation of skills in the lesson. Table 4.5 and Table 4.6 indicate manifestation of procedural and conceptual knowledge.

Table 4.6 Manifestation of Teacher A's procedural and conceptual knowledge: Lesson 2

Type of knowledge demonstrated by teacher	**Percentage manifestation**
Procedural knowledge	60%
Conceptual knowledge	40%

According to Table 4.6, Teacher A's use of conceptual knowledge improved from 20% in the preliminary lesson to 40% in Lesson 2. Teacher A tried as much as possible to explain conceptual meanings of items such as histogram and quartiles.

Table 4.7 illustrates the manifestation of instructional strategies during the lesson.

Table 4.7: Manifestation of instructional strategies in Teacher A: Lesson 2

Instructional strategy	**Percentage manifestation**
Lecture method	3%
Oral probing questioning	30%
Discussion	10%
Group work	30%
Individualised instruction	5%
Demonstration	20%
Other	2%

Figure graphically illustrates how Teacher A used instructional strategies during Lesson 2.

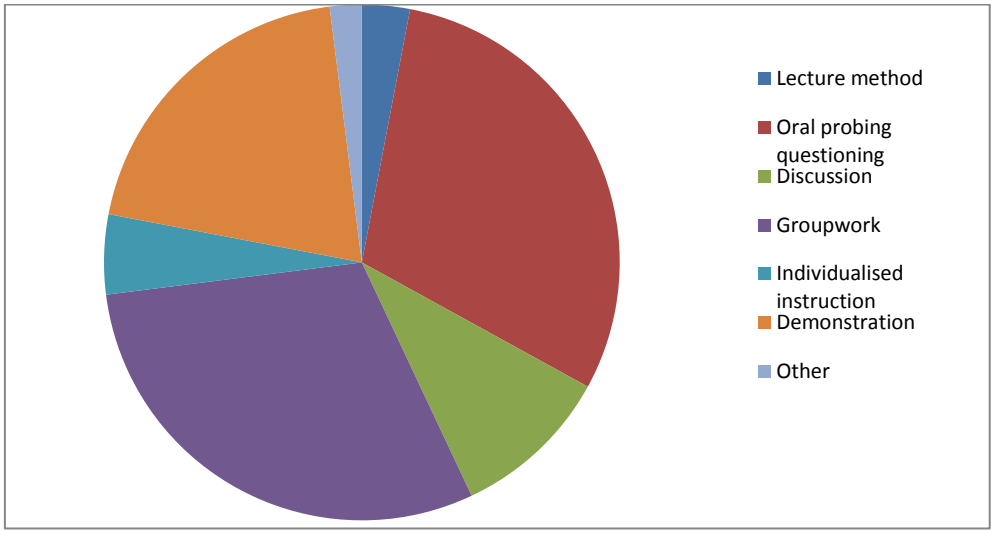


Figure 4.3: Manifestation of instructional strategies in Lesson 2: Teacher A

Table 4.7 and Figure 4.3 illustrate that during Lesson 2 Teacher A used a variety of instructional strategies moving away from using teacher-centred strategies to learner-centred instructional strategies.

The strengths of Teacher A observed in the lesson observed are summarised as follows:

- Teacher A identified key concepts, learners' prior knowledge, recommended real life examples, guidelines and anticipated learners' difficulties.
- A variety of instructional strategies was used during the lesson. Teacher A predominantly used learner-centred instructional strategies which allowed full learner participation.
- Homework was revisited during the lesson. After homework was done Teacher A asked learners to state the statistical graphs they knew. Learners mentioned the following graphs: box and whisker plot, pie chart, pictogram, line graph, bar graph, and frequency polygon.
- Learner participation was impressive with some learners presenting their solutions to problems on the chalkboard and explaining for those who did not understand.
- Oral probing questions were used by the teacher to solicit answers from the learners and to provoke learners' participation.
- No chorus answers were allowed as the teacher insisted that learners should raise their hands before they were allowed to speak.
- During the lesson, learners could differentiate the histogram from the bar graph and they could make rough sketches to show the differences. Teacher A gave learners the conceptual meaning of 'histogram' and demonstrated how to construct it using an example.
- Real life situations were used in examples and exercises given to learners.
- The discussion facilitated by the teacher consolidated what the learners presented.
- The teacher explained the procedure of using scale in constructing graphs and learners understood.
- Teacher A assisted learners with learning difficulties during the lesson. He even identified the learners who had problems and explained to them individually on how to construct the histograms. The majority of the learners

understood except one learner whom Teacher A requested to see at study time for remediation.

- Teacher A demonstrated that he studied the content very well as he explained the procedure of constructing the graphs.

However, Teacher A also manifested the following weaknesses during the lesson:

- He did not explain the concept “grouped data” to the learners.
- Teacher A only taught learners on how to work with scale without explaining its conceptual meaning. Hence some learners still struggled in selecting the appropriate scale. Some chose scales which did not accommodate the histograms which they wanted to construct.
- The examples Teacher A used did not include exercises on how to group data. The teacher did not give learners exercises which required them to group data first before constructing histograms.
- The Teacher did not give complex exercises for gifted learners.

After the lesson, Teacher B expressed satisfaction on how Teacher A conducted his second lesson arguing that there was a great improvement in how Teacher A managed his class. Teacher B went on to say that Teacher A showed that he recognised that learners could explain to others and this gave confidence and motivation to the learners.

The teacher tried to explain more on scale in class and invited learners who felt they needed more explanation to attend extra lessons. During the post-lesson discussion, the researcher revealed to the novice teachers that according to some researchers (Duller, 2008; Chance and Rossman), the use of technology especially projectors and computers is recommended in the teaching and learning of statistics. The novice teachers expressed gratitude on the revelation which I made. However, they argued that their schools did not have such assets and they themselves would be interested to observe some lessons in statistics where technology was adequately used. The researcher pledged to use technology in his next lesson as a way to demonstrate how technology is effective in a statistics classroom.

4.4.4.2 Summary and discussion of second classroom observation: Teacher B

The second classroom observation on Teacher B was attended by Teacher A and me. Teacher B's second lesson was on the construction of histograms. Teacher B admitted that he had benefitted from the lesson plan for his second lesson which was collaboratively prepared by me and the novice teachers because it contained details.

During the pre-lesson semi-structured interview Teacher B stated that the objective of the lesson to assist learners to be able to construct histograms. The teacher expected learner to be able to draw bar graphs and work with scale. Teacher B mentioned that he would use demonstration, oral probing questioning and example as instructional strategies. The key concepts that would be learnt during would be histogram and mean. Teacher B asserted that the use of real life examples during the lesson would promote learners' understanding.

I probed:

R: *Do you anticipate any learners' misconceptions and difficulties in the lesson?*

Teacher B's response was:

TB: *I expect learners to struggle in using graph paper and scale*

I went on to probe:

R: *How are you going to assist learners with misconceptions and difficulties in the lesson?*

Teacher B responded:

TB: *I will explain to the learners how graph paper is used and how the concept of scale comes.*

From the findings it is evident that Teacher B was prepared and ready for the lesson because he knew learners' prior knowledge, the depth of the content, learners' learning difficulties and how to eliminate these difficulties. After delivering his second lesson, the post-lesson semi-structured interview was conducted. During the interview Teacher B mentioned that he was not satisfied by how the lesson

proceeded. He expressed that although the majority of learners could construct histograms others struggled to use appropriate scale. Teacher B was also happy that learners in his class mastered key concepts of the lesson. He went on to elaborate that the learners could differentiate between a histogram and a bar graph.

I probed:

R: *Did you detect any specific learners' misconceptions that you had not anticipated and difficulties did during the lesson? If so, how did you address them?*

Teacher B's response was:

TB: *I noticed that some learners constructed inaccurate histograms because they had not mastered the concept of scale. I will conduct extra tuition and individualised instruction.*

I went on to probe:

R: *Do you think your strategies were effective in the lesson?*

Teacher B responded:

TB: *I believe so because the majority of learners could construct histograms although there is room of improvement. There is no thing that can be deemed to be absolutely perfect.*

During the interview Teacher B expressed that he was confident because had prepared for the lesson very well. He believed students learnt all that he wanted them to learn during the lesson because the majority could solve given exercises independently. Teacher B expressed that he learnt if the teacher uses visual aids the learners understand better. He went on to explain that learners fail to understand teachers' explanations in statistics because teachers were reluctant to use visual aids. Teacher B expressed that his target for improvement was to make each learners understand how to construct whatever statistical graph using scale. The teacher went on to say that if he would get another opportunity to teach the same lesson tomorrow, Teacher B expressed:

TB: *I would explain the meaning of 'grouped data' and how data is grouped. I would also emphasize more on the concept 'scale' because it is also a challenge even in Grade 12.*

The findings during the post-lesson semi-structured interview indicate that Teacher B was able to make reflection about his own teaching.

Table 4.8 and Table 4.9 illustrate the summary of some aspects which were recorded from the classroom observation.

Table 4.8: Manifestation of Teacher B's procedural and conceptual knowledge: Lesson 2

Type of knowledge demonstrated by teacher	**Percentage manifestation**
Procedural knowledge	70%
Conceptual knowledge	30%

Table 4.8 above shows that Teacher B began to use conceptual knowledge during Lesson 2 to explain the content to learners. The teacher tried as much as he could to explain conceptual meanings of items such as quartiles and histogram. Teacher B even went on to discuss with his learners the distinction between a histogram and a bar graph.

Table 4.9 Manifestation of instructional strategies in Teacher B: Lesson 2

Instructional strategy	**Percentage manifestation**
Lecture method	2%
Oral probing questioning	25%
Discussion	25%
Group work	15%
Individualised instruction	10%
Demonstration	20%
Other	8%

Figure 4.4 diagrammatically explains how Teacher B made use of some of the commonly used instructional strategies.

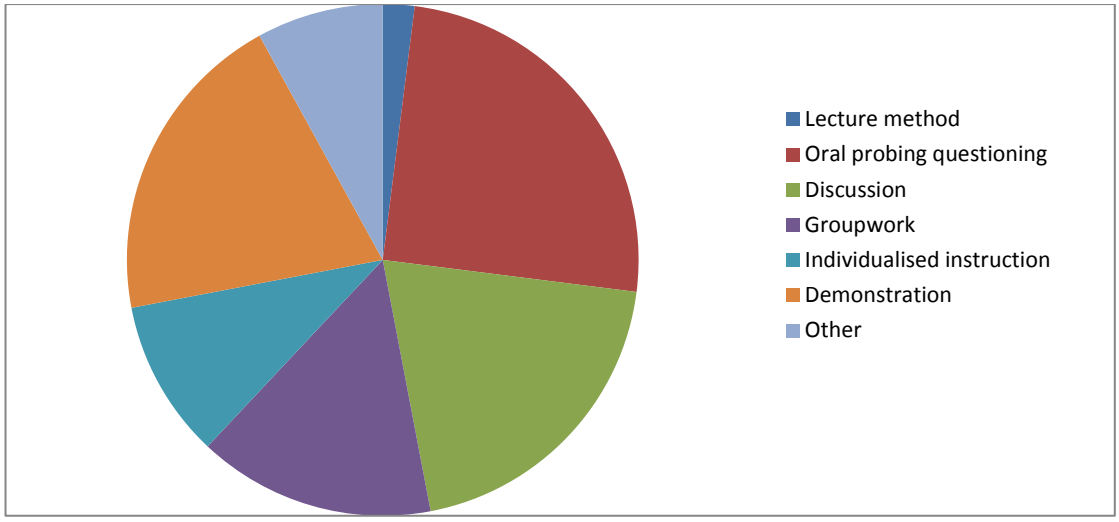


Figure 4.4 Manifestation of instructional strategies in Lesson 2: Teacher B

Some of the positive aspects of the lesson are as follows:

- Many items including objectives, resources and anticipated learning difficulties were stated on the lesson plan.
- Learner and teacher activities were explicitly mentioned. In the pre-lesson interview the respective teacher mentioned that he expected learners to struggle with the use of graph paper and scale.
- Teacher B identified the key concepts, learners' prior knowledge and anticipated learners' learning difficulties and misconceptions.
- The teacher revised homework with the learners.
- The teacher used oral probing questions to solicit answers from learners.
- No chorus answers were permitted from learners.
- There was better and full learner participation as compared to the first lesson.
- Learners' workbooks were marked by the teacher highlighting their errors and making a few comments.
- The teacher demonstrated dominion of content. Also, Teacher B demonstrated procedural knowledge when he explained how a histogram is constructed.
- Real life examples were used during the lesson.
- The teacher corrected learners who committed errors individually and then explained to the whole class.

- Teacher B defined the concept ‘histogram’ and explained its difference from a bar graph. The teacher also explained the concept ‘scale’ and how to use it.
- The teacher gave the learners relevant written work and homework.

The weaknesses which manifested during the lesson were:

- Teacher B did not explain the term “grouped data”. The teacher lacked conceptual knowledge to explain what grouped data was.
- There was no example and exercise given to learners on how to group data.
- There were no challenging exercises for gifted learners.

When asked about what technological assets the school had to enhance the teaching of statistics, Teacher B expressed that the school did not have computers and projectors. He argued that he could have used an overhead projector to demonstrate how to construct histograms. The only technological assets used were calculators which the school gave every learner at the beginning of the school year.

4.4.5 Third classroom observations on novice teachers

The third classroom observation was the final observation conducted on each novice teacher. The two novice teachers observed each other in the company of the researcher. The lesson plans were collaboratively prepared a day before classroom observations were conducted.

4.4.5.1 Summary and discussion of third classroom observation: Teacher A

During the pre-lesson semi-structured interview Teacher A stated that, after the lesson learners would be able to construct frequency polygons. He went on to mention that he also expected learners to have knowledge about the construction of histograms, the concept of scale as well as identifying midpoints of grouped data.

I probed:

R: *What teaching strategies are you going to use in the lesson? May you explain why you choose these?*

Teacher A’s response was:

TA: *I will use oral probing and demonstration as instructional strategies. By using oral probing I ensure fully participation of the learners. Demonstration will assist me to explain how to work with scale and make an accurate graphical representation of any given data.*

Teacher A went on to mention that the key concept during the lesson would be the frequency polygon and that he would use real life examples to do all the explanations. The teacher anticipated learners to have problems in drawing histograms and identifying mid-points of bars.

I went on to probe:

R: *How are you going to assist learners with misconceptions and difficulties in the lesson?*

Teacher A's response was:

TA: *I will use individual attention to learners and engage learners in extra tuition. This will enable the learners to practise and eliminate learning difficulties.*

The findings mentioned above indicate that Teacher A was well prepared to teach the content on frequency polygons. Teacher A went on to teach the lesson as planned. During the post-lesson semi-structured interview Teacher A expressed that the proceeded well according to plan because the majority of the learners could construct the graphs required. Teacher A went on to assert that the learners mastered the key concepts of the lesson because they solved exercises independently.

I probed:

R: *Did you detect any specific learners' misconceptions that you had not anticipated and difficulties did during the lesson? If so, how did you address them?*

Teacher's response was:

TA: *I did not detect any misconceptions.*

I went on to probe:

R: *Do you think your strategies were effective in the lesson?*

Teacher A responded:

TA: *I believe my strategies were effective because all learners could construct frequency polygons, which was my major objective.*

Teacher A expressed that during the lesson he felt very confident because he had engaged in thorough prior preparation. The teacher was also confident that the learners mastered the content taught during the lesson because he observed all learners busy writing the classwork without any difficulties. The lesson Teacher A learnt after teaching this content was that learners needed to be given tasks which require them to think critically and analytically.

I probed once more:

R: *What targets for improvement have you set yourself for this class, and are they realistic?*

Teacher A's response was:

TA: *My target is giving learners tasks which provoke analytic thinking.*

I further probed;

R: *If you were to teach this lesson again tomorrow, what would you do differently, and why?*

The teacher's response was:

TA: *I would give more challenging exercises to gifted learners, use teaching aids and give learners past examination questions.*

According to the responses given Teacher A was convinced that differentiated learning was pivotal to cater for learners of different abilities and needs.

The following is a summary of what transpired during the third classroom observation of Teacher A.

Table 4.10: Manifestation of Teacher A's procedural and conceptual knowledge: Lesson 3

Type of knowledge demonstrated by teacher	Percentage manifestation
Procedural knowledge	50%
Conceptual knowledge	50%

Table 4.10 above indicates that Teacher A's use of procedural knowledge and conceptual knowledge was balanced during the lesson. Although Teacher A was wanted learners to be able to construct frequency polygons, he was also concerned about learners knowing what each graph meant and how each graph was different from other graphs. Table 4.11 below illustrates how Teacher A used instructional strategies during Lesson 3.

Table 4.11: Manifestation of instructional strategies in Teacher A: Lesson 3

Instructional strategy	Percentage manifestation
Lecture method	0%
Oral probing questioning	30%
Discussion	20%
Group work	20%
Individualised instruction	10%
Demonstration	15%
Other	5%

Figure 4.5 below diagrammatically explains how instructional strategies were employed during Lesson 3.

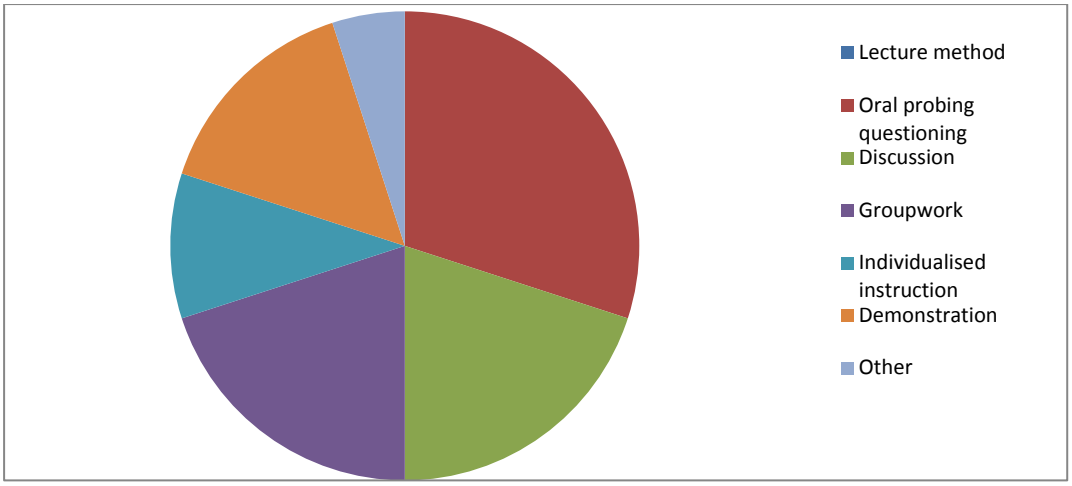


Figure 4.5: Manifestation of instructional strategies in Lesson 3: Teacher A

The following aspects about Lesson 3 of Teacher A were recorded:

- The lesson plan contained key aspects such as objectives, learners' prior knowledge and anticipated learners' learning difficulties.
- There was order in the classroom. All the learners were fully engaged and were very enthusiastic to learn. Each learner had a calculator, worksheet, textbook, mathematical set and graph paper to enable the construction of the required graphs. The learners sat in groups of three to allow them to discuss during classwork.
- The teacher checked learners' homework on histograms and corrected it.
- Teacher A explained again to all learners how to work with the scale after discovering that some learners faced challenges. The majority of learners understood the teacher's explanation.
- The teacher used a variety of instructional strategies: example, demonstration, oral probing questioning and group work. There was more learner participation with each learner fully engaged. Oral probing questions compelled learners to reason and think. The lesson was characterised by the use of a number of thought provoking questions from the teacher and full participation of the learners.
- The learners came up with some types of statistical graphs that can be constructed apart from histograms such as frequency polygon, compound bar graph and cumulative frequency curve.

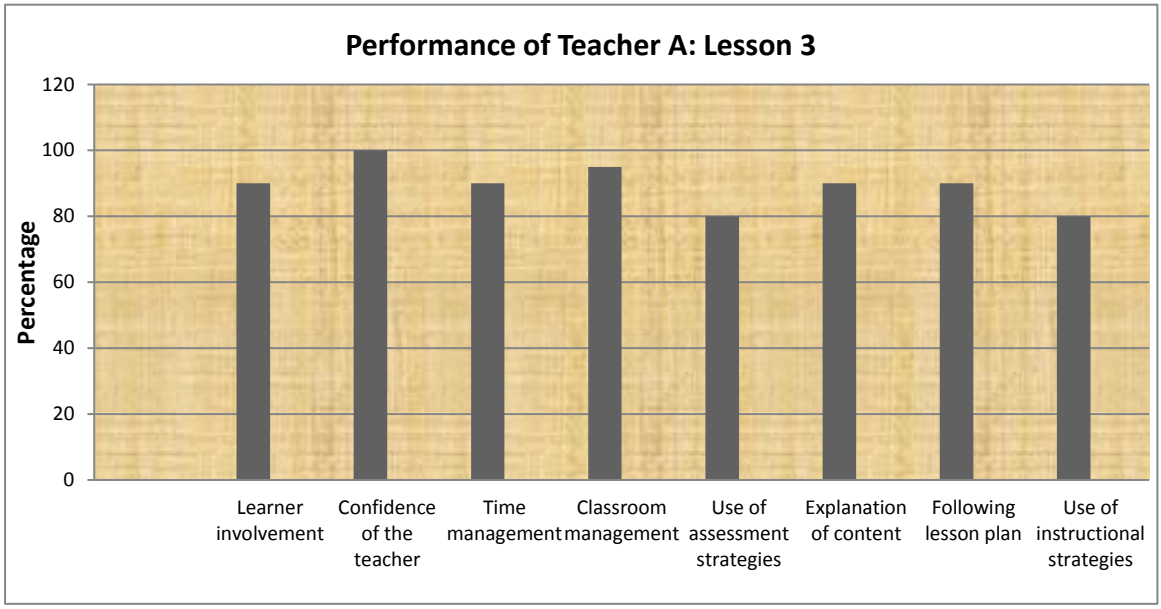


Figure 4.6: Performance of Teacher A: Lesson 3

During the lesson, there was a great improvement in questioning techniques used by Teacher A as compared to his two previous lessons. The teacher made the learners come up with answers to the oral questions that he asked. Teacher A used demonstration effectively to explain how to construct the frequency polygon using midpoints emphasising neatness and accuracy. The teacher also used procedural knowledge to explain how to construct the required graph by first explaining how to get mid-points of intervals in a table. Learners were requested to complete the table in their workbooks.

It was also observed that Teacher A visited some learners as individuals whom he knew always manifested problems to check their work. He assisted the learners to choose an appropriate scale and asked them to draw the axes and label them. The teacher demonstrated that his knowledge of learners' misconceptions and knowledge of learners' learning difficulties was improving. He could assist learners as individuals and asked them the parts of explanation they did not understand. The classwork and homework were given with enough questions targeting all types of learners including gifted learners. Teacher A argued that if he would be allowed to teach the same lesson again, he would try to use a projector to improve the quality of his lesson as suggested by some researchers (Duller, 2008; Chance & Rossman) who recommend the use of technology in statistics classrooms. Teacher B

expressed that he was impressed by the grouping method Teacher A used in his lesson and said he would also do this in his lesson. This clearly shows Teacher B learnt some good teaching practice from Teacher A.

4.4.5.2 Summary and discussion of third classroom observation: Teacher B

During the pre-lesson semi-structured interview I probed:

R: *What do you intend to achieve in the lesson that I will observe?*

Teacher B responded:

TB: *Learners should be able to draw frequency polygons*

Prior to the lesson Teacher B expected learners to have knowledge of the histogram, mean of grouped data and mid-point. The teacher asserted that using demonstration and oral probing as instructional strategies during the lesson would be best. Learners would be able to see how to work with scale. Teacher B continued to explain that the key concepts during the lesson would be the frequency polygon, histogram and mid-point. Real life examples would dominate the lesson to ensure conceptual understanding of the learners.

I went on to probe:

R: *Do you anticipate any learners' misconceptions and difficulties in the lesson?*

Teacher B's response was:

TB: *I expect some learners to fail to draw the graph because they have problems in working with scale.*

When asked how was going to assist learners with misconceptions and difficulties in the lesson Teacher B's response was:

TB: *I will conduct extra lessons and give learners more examples will be provided*

Teacher B's responses indicate that he was developing knowledge about the characteristics of his learners. It also shows that he was developing knowledge of strategies to assist learners with misconceptions and learning difficulties.

This lesson was jointly observed by Teacher A and me after previously engaging in collaborative lesson planning with Teacher B. During the lesson, all the learners were present, neatly dressed and seated in pairs in positions in which they had full view of the teacher and the chalkboard. After the lesson a post-lesson interview was conducted. Teacher B was asked if the lesson proceeded in the way he had planned. He expressed that lesson went on well as planned because learners to constructed frequency polygons without his assistance. The teacher stated that learners mastered the key concepts but there was need for doing more work on determining mid-points of classes.

I probed:

R: *Did you detect any specific learners' misconceptions that you had not anticipated and difficulties did during the lesson? If so, how did you address them?*

Teacher B's response was:

TB: *Learners could not easily determine mid-points of classes. I had to explain to them how to do it. I have arranged to conduct extra tuition*

Teacher B was not satisfied with the strategies he used to teach the lesson. He expressed that some few learners could not solve the exercises independently. The teacher confirmed that he felt confident because he studied various books to improve statistical content knowledge.

I further probed:

R: *Do you think your students learned all that you wanted them to learn in this session? What brings you to this conclusion?*

TB: *I think they learnt the content that I taught them because the majority of learners were able to construct frequency polygons independently.*

When asked what lesson he learnt about student learning from this class Teacher B responded:

TB: *If the teacher recognises each learner and appreciate each learner's contribution in class, the learners are motivated.*

Teacher B mentioned that his target for improvement was to assist learners of less ability to do solve challenging exercises on their own. He also expressed that given another opportunity to teach the same content he would teach learners the method of constructing histograms without involving histograms. Teacher B believed that it was the fastest method for learners to use.

Each learner had a calculator, hand-out, textbook, mathematical set and graph paper. The learning environment of Teacher B's class was conducive and suitable. Table 4.12 illustrates the summary of things that were observed.

Table 4.12: Manifestation of Teacher B's procedural and conceptual knowledge: Lesson 3

Type of knowledge demonstrated by teacher	**Percentage manifestation**
Procedural knowledge	45%
Conceptual knowledge	55%

Table 4.13: Manifestation of instructional strategies in Teacher B: Lesson 3

Instructional strategy	**Percentage manifestation**
Lecture method	0%
Oral probing questioning	30%
Discussion	17%
Group work	20%
Individualised instruction	15%
Demonstration	15%
Other	3%

Figure 4.7 below illustrates the use of instructional strategies during Lesson 3 by Teacher B.

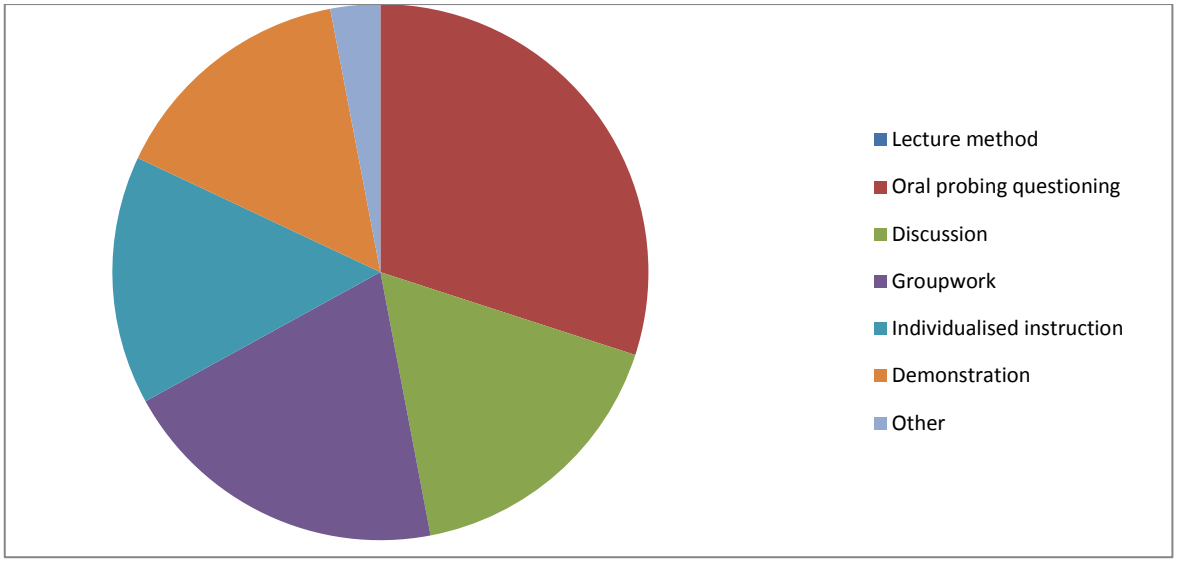


Figure 4.7: Manifestation of instructional strategies in Lesson 3: Teacher B

- The lesson plan contained key aspects such as objectives, resources, learners' prior knowledge and teacher-learner activities.
- Revision of homework given in the previous lesson was done. During the lesson, Teacher B followed the lesson plan step by step.
- There was full participation of all learners. Teacher B requested learners to explain their methods of solution on the chalkboard to their fellow classmates.
- Teacher B used a variety of instructional strategies to deliver the lesson asking a number of thought provoking questions which compelled learners to reason.
- Real life example on cell-phones was given to the learners in order to introduce frequency polygons.
- The teacher instructed learners to construct histograms using a given scale. Emphasis was made on the correctness of scale and the construction. Teacher B went round the classroom checking what the learners were doing. All the learners constructed correct graphs. Then the teacher instructed learners to join all consecutive mid-points using line segments.
- This demonstrates that Teacher B prepared well for the lesson. All learners were involved. The teacher found out that some of the learners failed to determine mid-points of intervals of grouped data. The learners corrected all the errors they had committed in the homework.

- Teacher B made use of learners' prior knowledge of mid-points to introduce the frequency polygon.

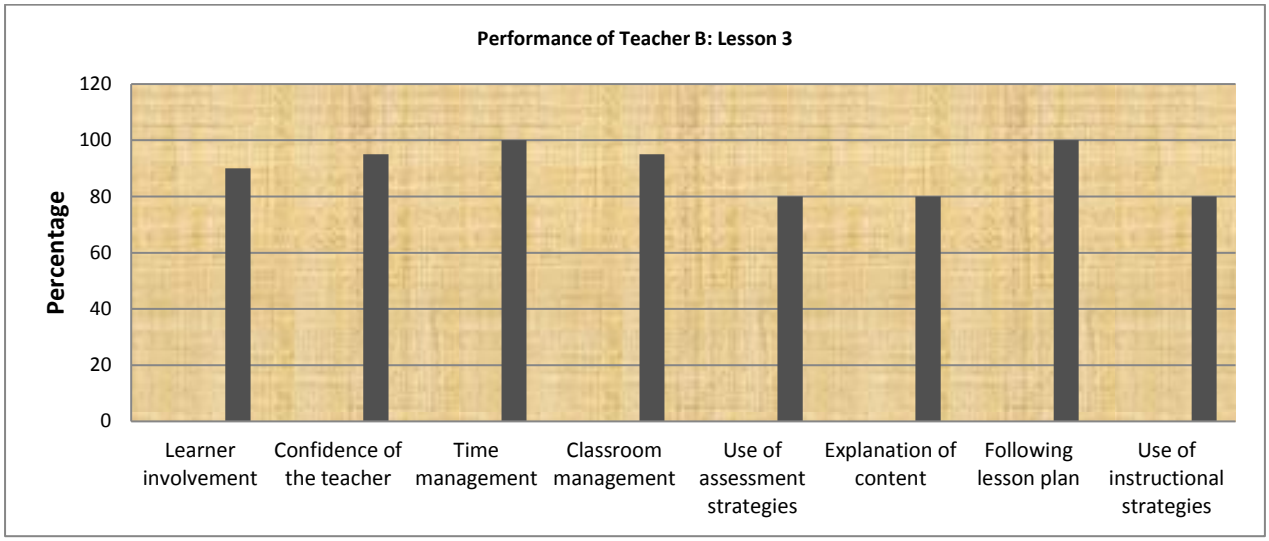


Figure 4.8: Performance of Teacher B: Lesson 3

Teacher B used procedural knowledge and conceptual knowledge to explain to the learners how to construct the frequency polygon. The use of a variety of instructional strategies including asking several oral probing questions encouraged learners to participate fully during the lesson. Teacher B identified learners who committed errors and explained to them how to construct accurate graphs. The teacher showed that his knowledge of learners' learning difficulties was developing. Teacher B also expressed that given another chance to teach the same lesson he would expose the learners to past examination questions and would also use a projector to demonstrate how to construct graphs.

4.4.5.3 Discussion on the teaching of statistics by the novice teachers

During the POT process, Teacher A and Teacher B followed the recommendations of policy documents and the annual teaching plan. During their lessons, Teacher A and Teacher B did not use technology to enhance their teaching in statistics. The teachers did not consider the recommendations by researchers (Duller, 2008; Chance & Rossman) who advocate for the use of technology in statistics classroom. This was due to the unavailability or such resources in their schools. The two teachers promised to suggest to their school authorities to buy computers and projectors.

I probed:

R: *What do you think schools should do to improve the performance of learners in statistics?*

Teacher A responded that learners should be exposed to projects whereby they collect data and analyse it themselves. Teacher B expressed the same sentiments emphasizing that there is need to engage corporate organisations to assist. However, it was surprising that in their lessons both teachers never used an assignment or exercise where learners would be obliged to collect and analyse data.

The two novice teachers used real data as recommended by Batanero and Diaz (2010) who argue that teachers should use real life examples and real data to foster conceptual understanding of statistics. Teacher A did not teach the construction of graphs effectively and this challenge was also faced by Teacher B. If the two teachers had used teaching aids and technology in their lessons this challenge was going to be addressed. Also, in both schools where Teacher A and Teacher B taught, I found out that the textbooks used had some errors. These findings concur with the study by Makwakwa (2012) who found out that teachers had problems in teaching the construction of statistical graphs and that statistics textbooks used in some schools contained errors which hampered conceptual understanding.

Learners in both Teacher A and Teacher B's classrooms showed excitement and interest in learning statistics. They showed positive attitude in studying the topic and asked for more extra work in the topic. The two teachers had a positive attitude towards the topic owing to the nature of their qualifications although this study did not measure this attribute. In interviews conducted, the two participants would always mention that they had thoroughly prepared and studied the content beforehand. It is assumed that a teacher with a negative attitude would not prepare adequately like what the two teachers did in terms of content. The positive attitude demonstrated by learners and teachers towards statistics in this study did not agree with Tishovskaya and Lancaster (2012) who in their study found out that statistics teaching and learning is hampered by negative attitude of learners and teachers towards the topic.

4.5 Summary of the second classroom observation on the researcher

The observers in this case, Teacher A and Teacher B, were both novice teachers. The following is a summary of what transpired during the second classroom observation on me:

- Full participation of learners with the teacher using a variety of instructional strategies such as oral probing, demonstration and example.
- Use of real life example and real data which facilitated learner understanding.
- Use of learners' prior knowledge of Cartesian coordinates which assisted in explaining how to plot point and subsequently construct ogives.
- Avoidance of chorus answers which gave learners the opportunity to reason and think critically.
- The use of conceptual knowledge to explain the meaning of 'ogive' and procedural knowledge on how to construct an ogive.
- The use of a projector to enhance teaching of how to construct an ogive.

During the post-lesson semi-structured interview, Teacher B had this to say about learner participation:

TB: *I learnt that learners understand better if they are asked questions and they themselves provide answers for these questions. The teacher should not give them answers but just plays the role of facilitator and judge.*

This statement demonstrates that Teacher B appreciated asking questions as a good strategy to involve learners in class. Teacher A echoed similar sentiments and went on to express that in all the lessons he attended as an observer or as the observed, it was striking that no learner asked questions in class openly. He argued that there should be strategies to allow learners to ask questions in an open discussion in class. However, Teacher A commended the researcher for soliciting answers from different learners in class and avoided using the same learners every time.

During the lesson, I detected that some of the learners had forgotten content about the Cartesian coordinates. He quickly revised with the learners so as to be able to plot points on the Cartesian plane. On the use of technology, Teacher B argued that

the projector was supposed to have been used in teaching histograms and frequency polygons. He mentioned that if he were to teach any statistical graphs in future he would resort to the use of technology especially the projector. Teacher A echoed the same sentiments.

During the post-lesson semi-structured interview, Teacher B asked the researcher what misconceptions and learning difficulties he had detected he responded:

R: *Yes, I detected that some of the learners had forgotten some analytical geometry concepts such as coordinates of a point in a Cartesian plane. They could not transfer this knowledge of analytical geometry to statistics. I had to explain to the learners.*

The statement by me made the novice to realise that statistics is dependent on mathematical concepts together with procedures and hence teachers can easily transfer some of their mathematical content knowledge to statistics. The novice teachers argued that although the exercises were relevant for the lesson, the researcher was supposed to include more challenging past examination questions since in the researchers' class there were more gifted learners. Teacher B argued the researcher could have given a project in which learners look for data themselves and represent the data graphically in histograms, frequency polygons and ogives. However, I stated that he was going to do that in the next lesson because this particular lesson was meant only to introduce the content on ogives. He further stated that the next lesson would be dedicated to exercises on ogives in which learners would be requested to solve past examination questions.

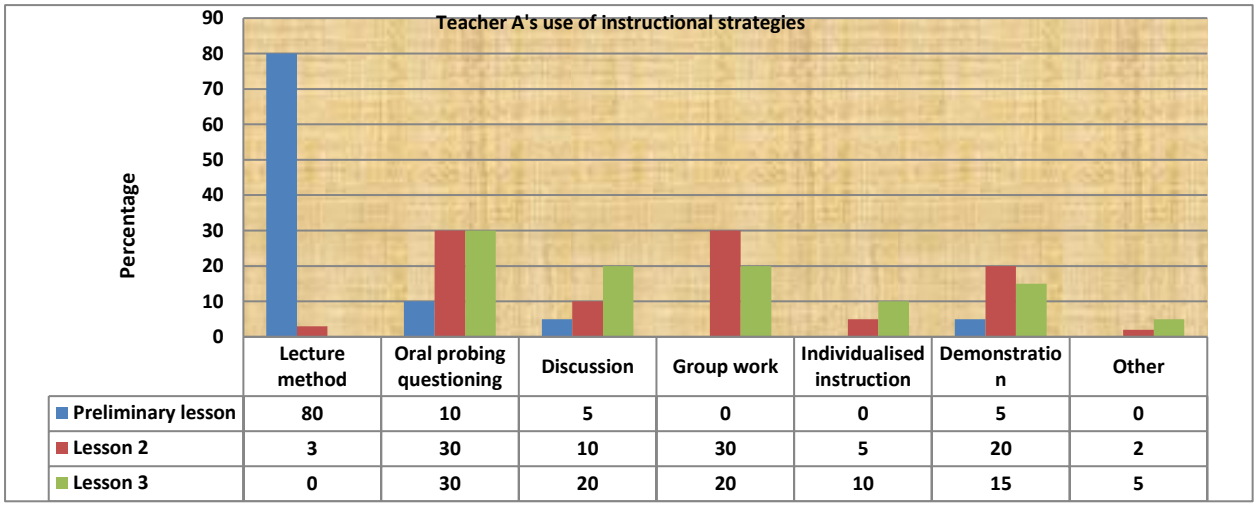
4.6 Effectiveness of the POT process on mathematics novice teachers

Peer observation of teaching is a process in which teachers reciprocally observe each other's teaching practice, sharing ideas on how to teach a particular discipline while espousing principles of mutual trust and respect. In this study, POT was carried out between me and two mathematics novice teachers in a certain circuit in Mpumalanga Province, South Africa. The topic which the process focused on was statistics teaching in Grade 11 by novice teachers. The POT process conducted was achieved using the model suggested by Bell (2002). The process started by conducting a pre-observation meeting with the two novice teachers. During this meeting, all modalities about the whole POT process were discussed. After this

meeting, classroom observations were carried out on the novice teachers as well as on me. During each classroom observation, the researcher and the novice teachers held pre-lesson and post-lesson semi-structured interviews discussing how each lesson would be conducted and how each lesson was conducted, respectively. Classroom observations were followed by a post-observation feedback meeting which was held to evaluate the whole POT process with the participants voicing their ideas and concerns. In this meeting, the process of reflection followed in which suggestions were made on how to make POT process a success in the teaching and learning of statistics. The discussions on the effectiveness of POT do not include my teaching practice because purpose of the study was to focus on how POT influenced the teaching practice of novice teachers only not mine.

4.6.1 Findings from classroom observations

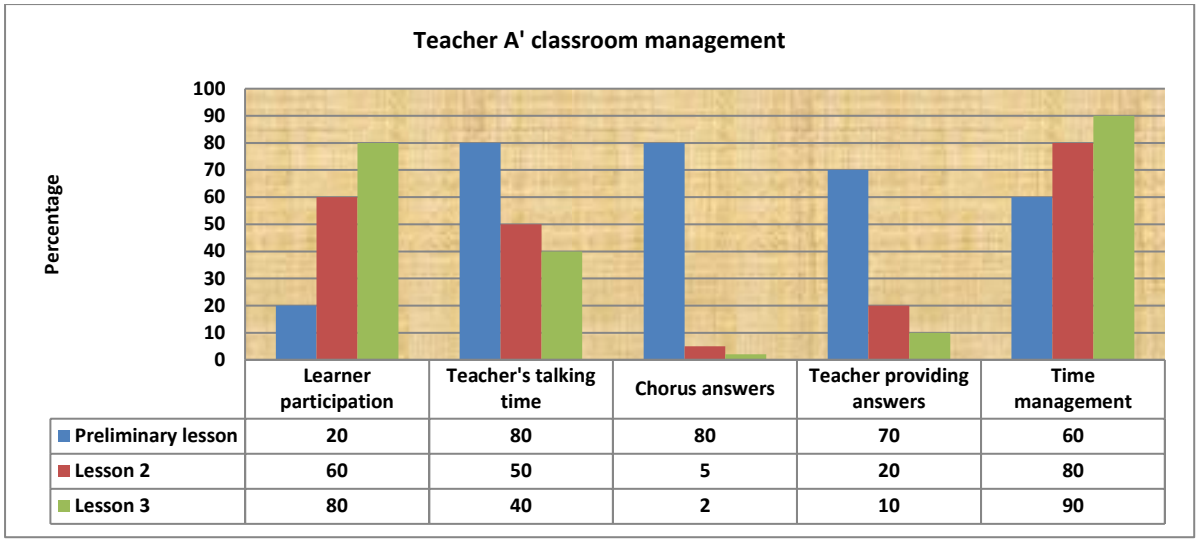
From the conducted classroom observations, the two teachers manifested changes in the use of instructional strategies and the manner in which they managed their classrooms. The graphs below show percentage shifts in the use of instructional strategies and some classroom management skills for both novice teachers.



	Lecture method	Oral probing questioning	Discussion	Group work	Individualised instruction	Demonstration	Other
Preliminary lesson	80	10	5	0	0	5	0
Lesson 2	3	30	10	30	5	20	2
Lesson 3	0	30	20	20	10	15	5

Figure 4.9: Comparison of instructional strategies used by Teacher A during POT

From Figure 4.9 above, it is clear that Teacher A's use of learner-centred instructional strategies improved. The preliminary lesson was dominated by lecture method which hampered learner involvement.

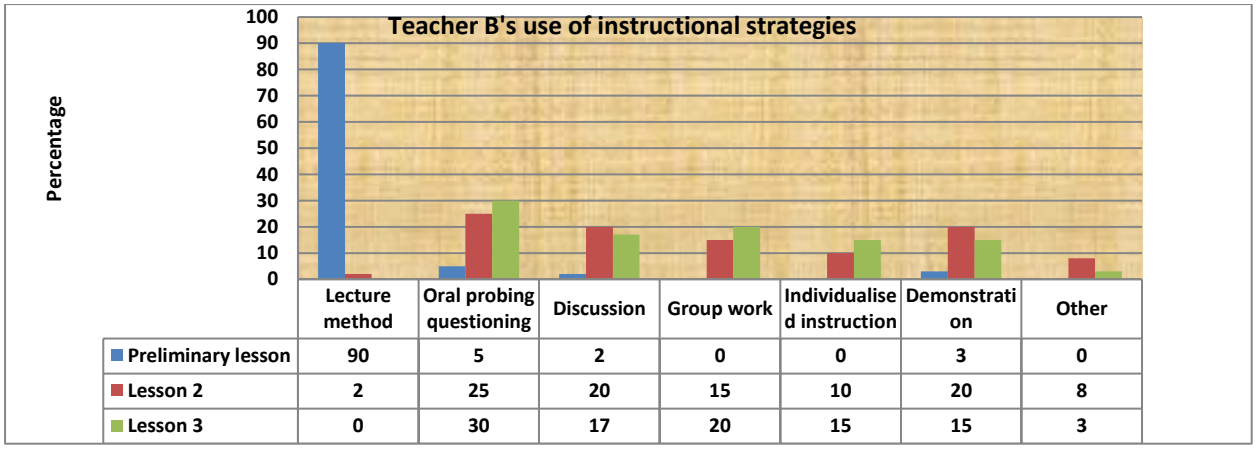


	Learner participation	Teacher's talking time	Chorus answers	Teacher providing answers	Time management
Preliminary lesson	20	80	80	70	60
Lesson 2	60	50	5	20	80
Lesson 3	80	40	2	10	90

Figure 4.10: Teacher A's classroom management during POT

Figure 4.10 graphically explains how aspects of classroom management of Teacher B improved during the POT process. Teacher A discarded chorus answers gradually as the POT progressed and learner participation improved during the last two lessons, that is, Lesson 2 and Lesson3 in which highest learner involvement was recorded. Teacher B's talking time declined by allowing learners to talk and ask questions in class.

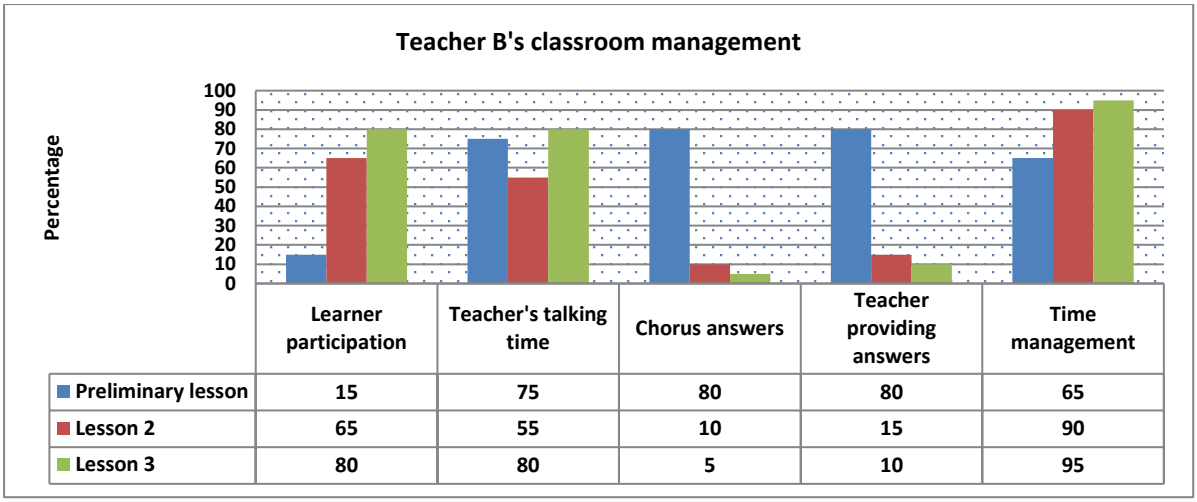
Teacher B's use of instructional strategies



	Lecture method	Oral probing questioning	Discussion	Group work	Individualised instruction	Demonstration	Other
Preliminary lesson	90	5	2	0	0	3	0
Lesson 2	2	25	20	15	10	20	8
Lesson 3	0	30	17	20	15	15	3

Figure 4.11: Comparison of instructional strategies used by Teacher B during POT

Figure 4.11 above illustrates comparison of the percentages dedicated to Teacher B's use of instructional strategies during the whole POT process.



	Learner participation	Teacher's talking time	Chorus answers	Teacher providing answers	Time management
Preliminary lesson	15	75	80	80	65
Lesson 2	65	55	10	15	90
Lesson 3	80	80	5	10	95

Figure 4.12: Teacher B's classroom management

Figure 4.12 graphically explains how aspects of classroom management of Teacher B improved during the POT process. The culture of chorus answers was eliminated gradually as the POT progressed and learner participation was more pronounced in Lesson 2 and Lesson3 in which learner involvement was the highest. Teacher B's talking time declined by allowing learners to talk and ask questions in class.

The majority of skills were improved by the novice teachers and it can be concluded that this phenomenon is a result of engaging the two teachers in the POT process. Also obtained from the study is that the two novice teachers appreciated the use of technology after observing me using a projector in his second classroom observation. The following information was obtained from the two teachers and from the classroom observations that were conducted:

- The two teachers were worried about the types of grade 11 mathematics textbooks in their schools because they contained some conceptual errors.
- I also found that two schools did not have enough textbooks.
- During the classroom observations, there was evidence that both novice teachers studied the statistics content thoroughly. This manifested in the teachers' explanations which showed depth and rigour. Also, the two novice teachers revealed that before classroom observations, they would engage in thorough studying of the content.
- At Teacher A's school, there was no other mathematics teacher who was competent to teach mathematics. He was the only mathematics teacher for

Grade 10 to Grade 12. Teacher B had an experienced colleague who never trained to teach statistics.

The shortage of textbooks and existence of conceptual errors in the few textbooks found in schools are concerns also mentioned by Makwakwa (2012) who asserts that statistics teaching and learning is hampered by the scarcity of textbooks and the existence of conceptual errors in textbooks. The finding that Teacher A and Teacher B did not have colleagues competent to teach statistics concurs with some researchers (Batanero, 2012; Makwakwa, 2012 and Mogari and Mogari, 2012) who argue that there is shortage of mathematics teachers in South Africa and that of those found in schools few of them are able and qualified to teach statistics.

4.6.2 Discussion of findings from the post-observation feedback meeting

The post-observation meeting was conducted at my school with the purpose of discussing the positive and negative aspects of the POT process. The following are the findings from the post-observation feedback meeting with the two novice teachers.

R: *How did you feel being observed by a colleague?*
TA: *At first I felt threatened because I am not used to observations conducted by colleagues. But as time went on I got used to the process*
TB: *I was uneasy because I was not very sure about the process because the interviewer informed me he had permission to conduct research from the Department of Education. I thought that if the researcher would find anything wrong in me he would inform the authorities which would jeopardise my job since I am still employed on contract.*
R: *How do you compare observation done by a colleague to that done by a supervisor or a mentor?*
TA: *During my teaching practice my mentor never observed my teaching. I cannot make any comparison. Being observed by a colleague was an exciting process because I got to know how other people excel in the classroom. Being observed by a supervisor makes me feel very nervous.*
TB: *A colleague is the best observer for me because I feel free to ask and contribute but mentors and supervisors instil fear in me. You cannot perform well in a threatening environment.*
R: *Do you think you benefitted during the course of this research?*
TA: *I benefitted a lot. Now my teaching beliefs have changed.*
TB: *I learnt a lot during the study. I have learnt on how to prepare for a lesson and attend to learners with learning difficulties.*
R: *What things went on well during the study?*
TA: *The process was well organised. Appropriate material was available during the process.*
TB: *Transport was available and the environment was very friendly.*
R: *What things did not go well and how can they be addressed?*
TA: *I was only observed three times teaching. If all lessons per topic are peer observed, the process yields better results.*
TB: *I teach two grade 11 classes. One of the classes was disadvantaged. If I was peer observed in both classes better results would come out.*

R: *Do you think you now have knowledge of content per grade after this study?*
TA: *I now have the knowledge. The interviews assisted me because each time there was a question about prior knowledge. This made me to realise that it is important to have knowledge of content per grade.*
TB: *The study motivated me to study the CAPS document and I ended up knowing content per grade.*
R: Which area in statistics teaching do you think you need special assistance?
TA: *I need assistance in teaching variance and standard deviation. Also in grade 12, I need more knowledge in regression.*
TB: *I need more assistance in teaching variance and to explain well to the learners this concept.*
R: *Will you continue to seek out and conduct peer observations outside this study?*
TA: *I enjoyed the observations because there was freedom. I personally think I will always participate in the same process in future.*
TB: *After this study I will discuss with my colleagues to observe me teaching other topics. This will make me improve in a lot of things*.
R: *What areas of your teaching do you think are going to improve after being observed by a colleague?*
TA: *The study made me to realise that I have to study the content in depth and solve all exercises before I come to class. I also learnt to attend to learners according to their abilities. Another aspect I learnt was the idea of making learners to explain their ideas to others.*
TB: *I will improve in explaining concepts and prepare for lessons. I will improve in identifying learner misconceptions and difficulties. I also learnt that it is important to always refer to policy documents.*
R: *What do you perceive as weaknesses in the method of peer observation?*
TA: *If both the observer and observed are not honest in feedback this might have negative impact on the process. Also the time involved in the process is too much to the extent that it becomes difficult to have observation on every lesson.*
TB: *Organising such a process is time-consuming. It is difficult to have each lesson to be observed. Also the process needs observers who are teachers of the subject. If someone is the only mathematics teacher in his school the process hits a snag.*
R: *How did the peer observation process affect your perception of your teaching?*
TA: *I now know that teaching is about sharing ideas with colleagues. If you decide to do things as if you exist in a vacuum you may teach learners wrong things.*
TB: *I believe we can do better we just work without promises of promotion. Peer observation has made me to realise and acknowledge the good in colleagues. I now know that learners can outperform teachers if they don't prepare and study.*
R: *What things do you think should be done to make peer observation effective?*
TA: *Peer observation can be made effective if observers are knowledgeable, if principals of schools are involved and if everyone within the school system believes in the process. I also think that if all teachers are trained to do peer observation of teaching without being judgmental the process is going to yield fruits. Another factor which I think may be effective is that there at every school there should be two or more mathematics teachers to enable peer observation to take place. I say so because you may find that someone comes teachers' training and is deployed to a school where he or she is the only mathematics teacher. At such a school no one orients him in the teaching of the subject and no one understands what is being taught.*
TB: *Observers should be honest and free to voice out their findings and recommendations. No one should be defensive. Colleagues who observe should know the content they are observing. I say because you may find a newly qualified being recruited to teach at a school where he or she is alone in the mathematics department. In terms of content no one in the school would be able to assist and orient that teacher. So I believe that when new teachers are being deployed the Department of Education should deploy such a teacher to a school where there are 3 or more teachers who would orient such a teacher.*

R: *What do you think your school should do to implement peer observation to improve the quality of teaching of statistics by new teachers like you?*
TA: *The school should have more mathematics teachers. If there are few mathematics teachers peer observation will be conducted with teachers who are not knowledgeable in mathematics. Time-tables can be drafted to allow peer observation to take place.*
TB: *My school should do a workshop on the concept of peer observation to highlight its benefits and objectives. This will dispel fears in teachers about the process.*
R: What do you think schools should do to improve performance of learners in statistics?
TA: *The learners should do a lot of projects of collecting data and calculate the measures of central tendency or variation themselves. Also content workshops should be organised solely in statistics.*
TB: *Content workshops are a solution to improve the quality of teaching and learning of statistics.*
R: *What do you think schools should do to improve performance of learners in statistics?*
TA: *Schools should invite curriculum advisors to conduct content workshops. Also principals must ensure that they purchase enough textbooks for learners and these textbooks should not have errors.*
TB: *Schools must buy projectors and computers to use when doing statistics. Also I believe that teachers in those schools must be people who always study the content in depth.*

Both novice teachers expressed that they felt nervous during the preliminary classroom observations. They both felt the process was a fault-finding mission, but gained confidence as the POT process progressed. The finding that both novice teachers felt nervous agree with the findings obtained by various researchers (Bell and Cooper, 2013; Gosling, 2002 and Blackmore, 2005) who argue that peer observation is threatening. On the other hand, Rayan (2013) asserts that peer observation should be conducted in a non-threatening environment and teachers who are committed to professional development should allow their colleagues to observe them.

The two novice teachers were excited by the POT process which they both said helped them learn from each other and from me. The two teachers expressed that they had the opportunity to share ideas and resources. Teacher B expressed that peer observation allowed colleagues to point out areas which needed improvement in his teaching and on the other hand Teacher A expressed that peer observation was good for the sharing of ideas which averts the teaching of wrong content and methods of solution and use of wrong instructional strategies in class. The views of the two teachers could be confirmed during classroom observations where they improved in their questioning techniques, involvement of learners during lessons and general classroom management. Various researchers (Hendry and Oliver, 2012; Hirsh, 2011 and Bell and Cooper, 2013) are in support of the comments expressed

by the two novice teachers and argue that the POT encourages discussion and critique and colleagues have the opportunity to highlight areas of improvement on the peer.

Both teachers expressed that during the POT process, they lost a lot of time and some lessons with other grades. This is a clear indication that POT was a time-consuming exercise for both teachers. The feeling that POT is time-consuming can be confirmed by some of the researchers (Rowe et al, 2010; Moore, 2013 and Thüy, 2012). However, the participants applauded the process and promised that they would like to engage in such a process because its benefits outweigh its limitations.

The two teachers stressed the importance of peer observers' content knowledge of mathematics and statistics. They argued that peer observers should be teachers who trained to teach mathematics at FET level. The two novice teachers did not have experienced colleagues in teaching mathematics and statistics in their schools. They said that the unavailability of experienced statistics teachers did not enhance the POT process.

When Teacher A was asked about whether he would participate in POT in future, he said he would participate because he felt there was freedom. This finding differs from the views of some researchers (Iqual, 2013 and Moore, 2013) who express that POT limits academics' and teachers' freedom and autonomy. Teacher B stated that he would request colleagues to observe his lessons in other topics apart from statistics. The two novice teachers also expressed that POT gave them the opportunity to put into practice what they knew theoretically about teaching statistics. This demonstrates that Teacher B saw the value of the POT process and wishes it to be extended to other topics in mathematics.

4.7 Nature of novice teachers' PCK development during the POT process

The demographic profile (Table 4.1) shows that the two novice teachers had degrees in engineering. Traditionally, training programmes in engineering have strong mathematical and statistical content. This suggests that both novice teachers had strong content knowledge in mathematics and statistics. Also, the two teachers

revealed that they studied some modules in statistics at university level in their qualifications. This also suggests that Teacher A and Teacher B had statistical content knowledge. The fact that each novice teacher had a PGCE in mathematics education implies that the two teachers had some PCK to teach mathematics and this PCK was used to attempt to teach statistics in grade 11.

During their studies to obtain PGCE, the two teachers never studied modules in the methodology of teaching statistics. This finding concurs with Wessels (2008) who found out that teacher preparation programmes in 21 universities in South Africa produced teachers with inadequate PCK in the teaching and learning of statistics. The findings on Teacher A and Teacher B agree with Batanero (2012) who argues that fewer teacher training programmes produce competent teachers in statistics. The shorter teaching experiences of the two teachers suggest that the teachers had less PCK in statistics teaching concurring with De Jong (2010) and Schneider & Plasman (2011) who argue that PCK improves with classroom experience.

4.7.1 Teacher A's PCK development

During the pre-observation meeting, Teacher A acknowledged the support of his lecturer who always visited to observe him teaching mathematics lessons during teaching practice. The support rendered by the lecturer might have contributed to shape Teacher A's PCK development in the teaching of mathematics. The teacher had four months teaching experience when this study was conducted. Furthermore, it was found that Teacher A never taught statistics before, which shows that he had no teaching experience in statistics. Teacher A further explained that he never attended any workshop focusing on the teaching and learning of statistics but attended workshops focusing on other topics. This suggests that Teacher A did not have adequate PCK in the teaching of statistics.

The graph below summarises how Teacher A contributed in the classroom interactions in the three lessons observed during the POT process. In the graph below "Teacher's talking time during lesson" refers to the amount of Teacher A's talking time including the time the teacher dedicated to asking questions.

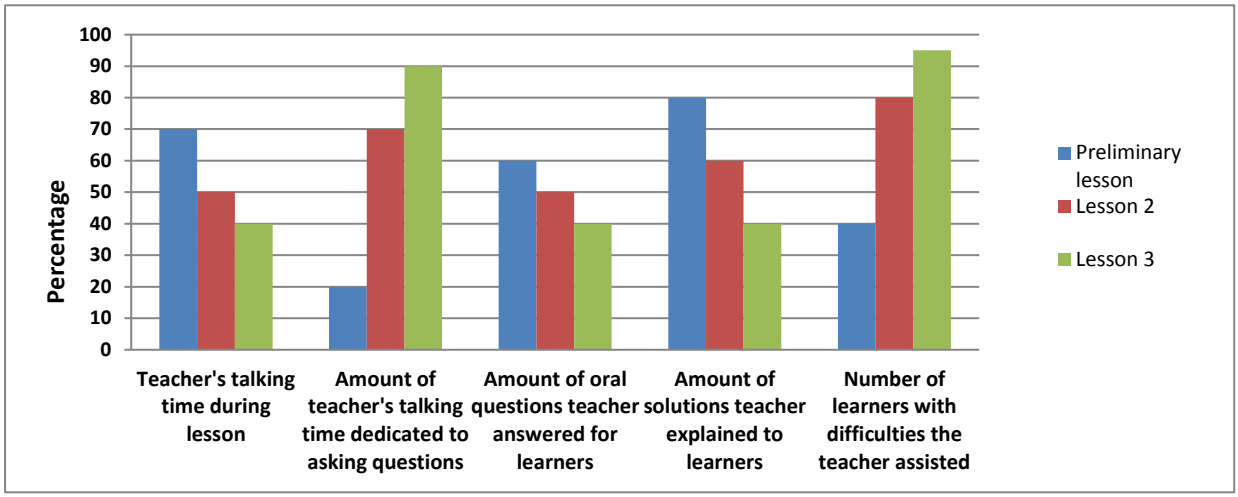


Figure 4.13: Teacher A's activities in class

According to Fig 4.13 above, Teacher A's talking time diminished during the course of the POT process and also the teacher managed to facilitate class discussions in which learners obtained solutions to questions given in class.

4.7.1.1 Development of Teacher A's knowledge of the subject matter

During the preliminary lesson, Teacher A demonstrated content and conceptual knowledge by defining the concept 'mean' to the learners. However, the teacher reduced the lesson into a series of procedures when it came to obtaining median and quartiles. The teacher was supposed to foster conceptual understanding first before emphasising procedures as recommended by Ijeh (2012) and Star (2002). These researchers assert that a combination of both conceptual knowledge and procedural knowledge assists in deepening learners' understanding. In the post-lesson semi-structured interviews, Teacher A always mentioned that he had studied the content in depth using various sources. This revelation suggests that Teacher A's content knowledge in statistics was improving.

During Lesson 2, Teacher A defined the concept 'histogram' and differentiated it from a bar graph. The teacher went on to use procedural knowledge to explain the construction of the histogram. The teacher combined both procedural and conceptual knowledge hence there was more learners' understanding than in the preliminary lesson. In Lesson 3, Teacher A used both conceptual and procedural knowledge to teach frequency polygon and learners understood better than the

previous two lessons. According to Engelbrecht *et al* (2005), Teacher A's content knowledge was improving because of balancing the combination of both conceptual and procedural knowledge. The teacher demonstrated that he possessed deeper statistical knowledge which was above grade 11 content during lesson delivery. Teacher A never committed content errors and prepared thoroughly for each lesson. These findings suggest that Teacher A's content knowledge to teach statistics was developing.

4.7.1.2 Development of Teacher A's knowledge of instructional strategies

According to Figure 4.1, Teacher A's talking time in the preliminary lesson was more than in any other lesson. Teacher A's talking time decreased in Lesson 2 and went on the decrease also in Lesson 3. On the contrary, Teacher A in his talking time asked fewer oral probing questions in the preliminary lesson and more oral probing questions were asked in Lesson 2 and Lesson 3. As the teacher increased the amount of oral probing questions the more learners participated in the lesson. During the preliminary lesson, there was less interaction with learners because the teacher was doing almost everything for the learners hence they had less opportunity to develop critical and analytic thinking. Although Teacher A used a familiar context as an example as recommended by Shulman (2007), the example used was inadequate because he only dwelt with a data set of an odd frequency. This led to learners' misunderstanding the determination of quartiles. Teacher A had to re-teach the content in an extra lesson.

During Lesson 2, Teacher A avoided chorus answers when treating histograms. Learners answered oral questions and presented their solutions and could do the explanations themselves. Also, during the Lesson, Teacher A used an effective example to teach the construction of histograms. Although the learners struggled with 'scale', the lesson delivery was better than in the preliminary lesson because learners were involved and fully engaged. During Lesson 3, more learners participated than what they did in the two previous lessons. Notably, in the lesson, Teacher A used the grouping method as a strategy which according to Ijeh (2012) and Adodo and Agbayewa (20110 promotes effective lesson delivery and learners' understanding in class. According to Ijeh (2012), PCK is acquired as the teacher interacts with learners every day. This implies that from the preliminary lesson to

Lesson 3, Teacher A's PCK was improving with more teacher-learner interactions. This shows that the instructional strategies Teacher A used became more and more learner-centred from the preliminary lesson to Lesson 3. According to Rollnick *et al* (2008), Teacher A's PCK was developing because he increased interaction with learners by asking them to explain on the chalkboard and engaging in discussion. Teacher A's statistical knowledge for teaching [SKT] was also increasing as he managed to engage his class in discussion about statistics (Groth, 2007).

Teacher A used real data and real life examples. According to Shulman (2007), the use of real life examples drawn from real life situations assists to transform the subject matter into a comprehensible form to the learners. Teacher A sent some learners to the chalkboard to explain to the class how they obtained their solutions. However, there was lack of challenging exercises for gifted learners in the class who finished solving the exercises and were requesting for some more which the teacher did not provide. Homework was given to the class, but the exercises did not challenge gifted learners. The teacher could have used past exam questions.

During Lesson 3, Teacher A supplied adequate exercises to the learners. Learners sat in groups. During the other two initial lessons, learners sat as individuals. According to Ijeh (2012), the grouping method facilitates learner-learner interaction and collaborative learning in the learning of statistics by learners. An effective classroom lesson is achieved by using the grouping method (Ijeh, 2012).

The concept of "frequency polygon" was not defined but the procedure to construct the graph was well explained. There was great improvement in the quality of exercises given because the questions of all levels of difficulty according to Bloom's taxonomy were there. This benefited gifted learners as well as the disadvantaged learners. In all the classroom observations conducted for Teacher A, the teacher provided resources to the learners but neither technology nor teaching aids were used.

4.7.1.3 Development of Teacher A's knowledge of misconceptions and learners' learning difficulties

During the preliminary lesson, Teacher A could not obtain learners' learning difficulties and misconceptions because of lack of questioning techniques. Because

the teacher could not mark all the learners' work, some of the problems learners faced could not be identified and solved. Whilst Teacher A appeared to have improved much in terms of statistical content knowledge, more work needed to be done in terms of knowing learners' learning difficulties and misconceptions. The teacher began to engage learners by asking thought provoking questions during Lesson 2 and Lesson 3 which improved dialogue in the classroom to some extent.

During Lesson 2, Teacher A asked a lot of oral questions in class to assess learners' performance and to identify those learners who had challenges. The teacher moved from one learner to another in class marking written work. Teacher A identified some learners who were not able to finish the construction of the histogram he had given them. The teacher assisted the two learners individually and availed himself to all the learners assisting them and advising them to attend extra tuition. During Lesson 3, Teacher A used learners' prior knowledge, pre-activities and corrections of homework to identify learners' pre-conceptions and learning difficulties in the construction of histograms. According to Bukova-Güzel (2010), the use of learners' prior knowledge improves knowledge of learners' learning difficulties. Teacher A identified that learners had problems with the use of scale and determining mid-points of grouped data. According to Penso (2002), teachers should address anticipated learners' learning difficulties during lesson planning and preparation. During the last two lessons, Teacher A tried as much as possible to mark learners' written work and engage in classroom discussions. According to Ijeh (2012), teachers develop knowledge of learners' learning difficulties through analysis of learners' written work and engaging learners in oral discussions. In this case, it can be concluded that Teacher A's knowledge of learners' misconceptions and learners' learning difficulties improved.

4.7.2 Teacher B's PCK development

Teacher B explained that he never studied any module in the methodology of teaching statistics. When asked if he had any chance of teaching statistics on teaching practice, the Teacher B responded:

TB: *No, I did not teach statistics, but I taught other topics.*

Teacher B applauded the support of his mentor during teaching practice. The teacher mentioned that the mentor would always engage him in post-lesson discussions. Also, Teacher B acknowledged the visits by his lecturer to observe his lesson. The support from the mentor and lesson observations conducted by the lecturer could have shaped the PCK of Teacher B in the teaching and learning of mathematics. In the pre-observation meeting, Teacher B mentioned that he had 1 year 6 months teaching experience and that it was his second year to teach statistics. On teacher development workshops, the teacher said that he attended three of them, but none of them focused on statistics. The information above suggests Teacher B did not have much experience in the teaching of statistics and that he did not have adequate PCK to teach statistics. The following graph summarises how Teacher B was involved in the lessons he conducted. In the graph below "Teacher's talking time during lesson" refers to the amount of Teacher B's talking time including the time the teacher dedicated to asking questions.

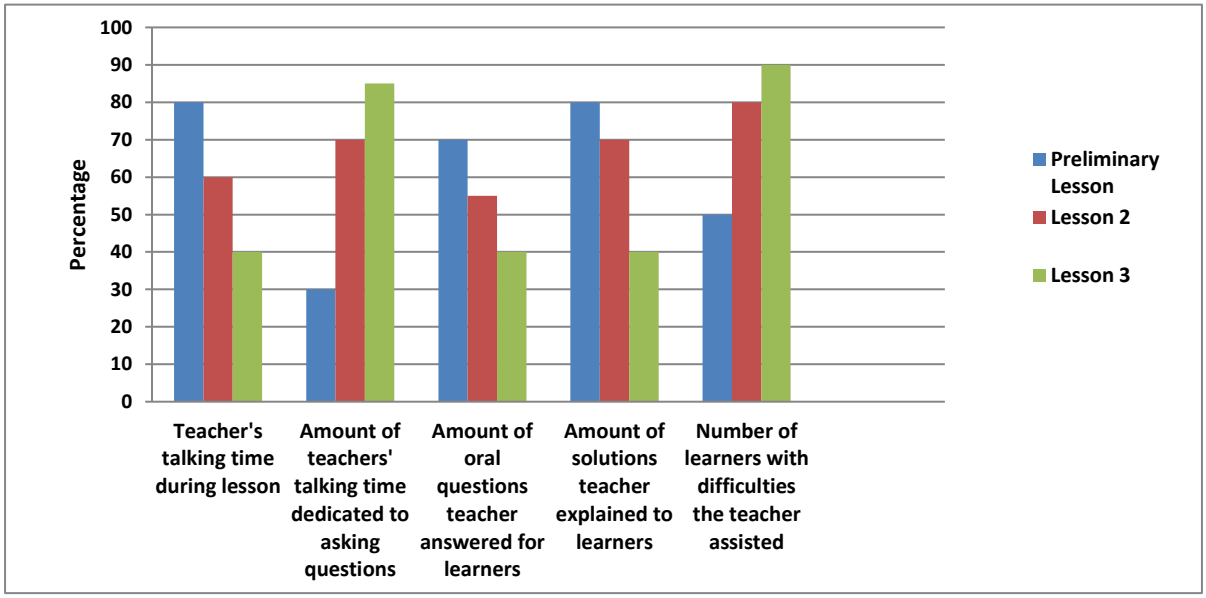


Figure 4.14: Teacher B's activities in class

From Figure 4.14 above, it emerges that interaction between Teacher B and learners became more pronounced during the progress of the POT process. The culture of having the teacher dominating the teaching and learning process shifted to a

dynamic atmosphere in which learners suggested solutions to questions and problems.

4.7.2.1 Development of Teacher B's knowledge of the subject matter

During the preliminary lesson, Teacher B skillfully used procedural knowledge to explain concepts. He explained the procedure to determine median and quartiles very well. However, the concepts were not well explained. This finding concurs with the study by Makwakwa (2012) which found out that concepts (mean, mode, median, variance, standard deviation and quartiles) were not defined well by teachers and the methods to obtain them were not explained well in grouped data. Teacher B was supposed to combine both conceptual and procedural knowledge as recommended by Engelhecht *et al* (2005) and Star (2002) who advocate the use of both conceptual approach and procedural approach in lessons. The teacher dwelt much on the procedures to determine mean, median, and quartiles.

During Lesson 2, Teacher B explained the concept 'histogram' and went on to explain the procedure to construct the required graph. Both procedural knowledge and conceptual knowledge were used and learners understood better than in the preliminary lesson though they still struggled with scale. During Lesson 3, the teacher demonstrated content knowledge more than in the previous two lessons because he dominated the content, explained concepts and procedures well and was very confident with the content. Teacher B balanced explanation of procedure of constructing frequency polygon and the definition of concepts 'frequency polygon' and 'mid-point'. The teacher made sure learners understood the meanings and steps to represent these concepts graphically. According to Leong (2013) and Mishra & Koehler (2006), teachers with strong content knowledge are able to explain concepts and procedures. This implies that Teacher B's content knowledge improved. In all classroom observations conducted, Teacher B was very confident and demonstrated that his statistical knowledge for teaching was improving because of studying thoroughly before conducting lessons.

4.7.2.2 Development of Teacher B's knowledge of instructional strategies

Teacher B's dominant instructional strategies were the lecture method and demonstration in the preliminary lesson. In the first lesson observed, the teacher posed few questions in class. As the topic progressed, Teacher B began to ask more probing questions to learners in class. In Lesson 2, Teacher B used oral probing questioning, example and demonstration to teach the content on histograms. There was better learner participation than in the preliminary lesson because Teacher B began to involve learners. In the previous lesson, the teacher would ask questions and learners would respond in chorus to give answers. In lessons 2, there was more interaction in class with the Teacher calling learners who were participating by their names to eliminate chances of obtaining chorus answers. One striking thing in all lessons observed is that no learner asked a question openly in class to solicit for the teacher to explain more clearly. It was the teacher who would ask and learners answering. Some learners took advantage to ask questions when the teacher was making rounds in class. According to Sowey (2006), asking questions indicates student involvement in the learning process and student learning is enhanced when the teacher solicits challenging questions. For example, during the post-lesson semi-structured interview of Lesson 3, Teacher B, when asked what he learnt about student learning in class, he responded:

TB: *I learnt that learners learn more if they are exposed to more work and if the teacher asks them thought provoking questions.*

During lessons, neither technology nor teaching aids were made use of to facilitate conceptual understanding recommended by Duller (2008) and Chance and Rossman (2006). Teacher B could have used technology in his class to improve the quality of teaching.

Teacher B used real life examples in his lessons and a balance of combination of instructional strategies in the last two lessons. According to Shulman (1986) and Loughran (2004) when teachers use examples, demonstrations and analogies, their knowledge of instructional strategies improve. This information implies that Teacher A's knowledge improved due to more use of examples and a combination of other instructional strategies. However, more instructional strategies classroom such as

problem solving and projects where learners collect their own data could have been used to foster conceptual understanding and provoke learners' critical and analytic thinking. Learners were actively involved in writing classwork, but there were fewer challenging exercises for application of knowledge.

4.7.2.3 Development of Teacher B's knowledge of misconceptions and learners' learning difficulties

During the preliminary lesson when Teacher B asked questions to learners, they responded in chorus answers. Teacher B did not give learners an opportunity to ask questions in class and open up to show their misunderstanding. The teacher was supposed to be tactful in soliciting for answers from the learners so that learners could bring to light some misconceptions they might have had. Teacher B had limited ability to articulate thought provoking questions to learners. Although Teacher B made rounds in class, some learners' difficulties were not identified. In the post-lesson interview for preliminary lesson, Teacher B admitted he did not ask thought provoking questions.

During Lesson 2, Teacher B tried to ask questions and could easily identify learners' learning difficulties in working with scale and promised to conduct extra tuition. In Lesson 3, Teacher B quickly detected that learners could not work with grouped data when he marked their work. In the post-lesson interview for Lesson 3, the teacher admitted that he did not teach this part well and would conduct extra tuition and revision to eliminate this difficulty. In Lesson 3, Teacher B knew some of the learners who were struggling. The teacher attended to those learners with difficulties as they were writing classwork. However, Teacher B could have achieved more if learners were exposed to more challenging exercises and past examination questions. Teacher B developed a culture of marking learners' written work during and after lessons and involved learners in classroom oral discussions during Lesson 2 and Lesson 3. According to Ijeh (2012), teachers develop knowledge of learners' learning difficulties through analysis of learners' written work and learners' involvement in discussions. This suggests that Teacher B's knowledge of learners' learning difficulties improved. Also, Teacher B used learners' prior knowledge in class, attended to individual learners and had anticipated learners' learning difficulties.

According to Bukova-Güzel (2010), Teacher B's knowledge of learners' learning difficulties improved.

4.8 Reflection from the POT experiences

The post-observation meeting was conducted at the researcher's school for feedback and overall evaluation of the whole POT process. I thanked the two novice teachers for their participation and cooperation during the study. He also appreciated their positive behaviour and willingness to learn and encouraged them to continue with the same spirit in their upward developmental trajectory.

During the meeting, Teacher A expressed gratitude and satisfaction on the provision of transport by me to and from observation centres. The two novice teachers mentioned that that all procedures agreed upon were followed despite some challenges. Teacher B stated that the times for classroom observations and semi-structured meeting agreed upon were adhered to. Teacher B was impressed by the choice of statistics as the topic for the study. He argued that pre-service training programmes for teachers at universities take for granted that when at teacher does methodology in mathematics teaching he or she can teach effectively which is not always the case. On the other hand, Teacher A appreciated the contribution his fellow novice teacher (Teacher B) for bringing brilliant ideas during lesson delivery. He commented that he was encouraged by seeing a fellow novice teacher delivering effective lessons as if he had been in the teaching profession for many years and he pledged to adopt some of the ideas in his future lessons. I expressed that before the study, he never anticipated to obtain brilliant ideas and techniques which the two novice teachers demonstrated in their classrooms. He commended the two novice teachers for shaping his pedagogical perspectives and bringing to nought the stigma novice teachers always experience when they join the teaching profession because they are traditionally deemed to be incompetent.

The two novice teachers applauded me for using a projector to demonstrate to learners how to construct statistical graphs. They said they would talk to their principals to procure and provide technological gadgets for the effective teaching of mathematics and statistics. However, the two novice teachers had various concerns about the POT process despite the good experiences they encountered. Firstly, they

lamented that the POT process consumed a lot of time. The comment about POT as a time-consuming process concurs with Robinson (2010) who argues that a lot of time is wasted in the process. The two novice teachers expressed that during the time they spent travelling and conducting the study, they were supposed to attend to other classes in their respective schools. There would be need to compensate the teaching time lost during the study by conducting extra lessons with the classes affected. I extended his heartfelt apologies to the two novice teachers who in turn accepted my apologies. Teacher A argued that the classroom observations were supposed to be conducted until the completion of the topic for him to fully benefit. Teacher B suggested that the next time such types of activities are conducted; principals should be involved so that they learn about the plight of novice teachers.

When the teachers were asked to suggest what the school should do to implement peer observation to improve the quality of teaching of statistics by new teachers, the responses were:

TA: *The school should have more mathematics teachers. If there is only one mathematics teachers, peer observation of teaching will be conducted with teachers who are not knowledgeable in mathematics. The process would not be effective. The school can draft time-tables for peer observation to take place.*

TB: *My school should conduct a workshop on the concept of peer observation of teaching to highlight its benefits and objectives. This will dispel fears in teachers about the process.*

Teacher A argued that it is not a wise idea to appoint a peer who does not teach the same subject because the observer will not be well versed with the content. On the other hand, the reciprocal aspect of POT would not be fully satisfied because the teachers involved in the process would be coming from different subject areas. The observer would only concentrate on the classroom environment and other things leaving analysis of the content being taught. Teacher B suggested that for POT to be a successful enterprise, there must be training of teachers on how the process is done before the process is implemented.

I continued to ask another probing question:

R: *Will you continue to seek and conduct peer observations outside this study?*

Teacher A responded:

TA: *I enjoyed the observations because there was freedom. I personally think I will always participate in the same process in future.*

On the same question, Teacher B also expressed the following words:

TB: *After this study, I will discuss with my colleagues at my school and encourage them to observe me teaching other topics. This will make me improve in a lot of things*.

Teacher A stated that he would always engage in peer observation in future. Teacher B also followed suit to echo the same sentiments which is indicative of the fact that the two participants enjoyed the POT process although it appeared threatening in the initial stages of the study. I noted the nervousness of Teacher B in the preliminary lesson because his eyes were glued on the peer observers presumably imagining what they were recording. After the post-lesson semi-structured interview, the teacher became more relaxed. The responses by the two participants demonstrate that the two teachers were overwhelmed by fear in their first lessons when they were peer observed. As time progressed, the two teachers gained more confidence in the lessons observed. This implies that POT made the participants gain confidence in themselves in whatever circumstances they found themselves in whether being observed or not.

Teacher A acknowledged that he learnt classroom management techniques from the researcher and Teacher B, especially the need to make learners participate fully in class. Teacher B echoed similar sentiments and went on to applaud me for admitting that I also learnt a lot of things from the two novice teachers, especially the methods of solution to exercises. The two novice teachers noted how detailed my lesson plans were and pledged that they would emulate the good practice in future lessons.

4.9 Conclusion

In this chapter, the demographic profiles of the participants were explained. Explanation of the POT process, description of all classroom observations and semi-structured interviews conducted are given. Data obtained were presented and analysed and discussion of results followed. The chapter also described the PCK development of the two novice teachers during the POT process. The study was conducted using a case study design. The results and findings obtained during the

study indicate that the researcher confidently concluded that the POT process improved the PCK of the mathematics novice teachers. The next chapter presents the discussion and recommendations.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the major findings of the research on peer observation of teaching as a strategy to enhance the teaching and learning of statistics in a grade 11 South African classroom by mathematics novice teachers. It goes on to give an overview to prove that the research questions and aims which were stated in Chapter 1 have been addressed and achieved. The chapter also draws conclusions, gives highlights of limitations, and provides conclusions and recommendations directed to the Department of Basic Education and to researchers in the teaching and learning of statistics.

5.2 Summary of the study

This section gives an overview of the whole study. Chapter 1 outlined the background and introduction of the study expressing the aim, objectives and research questions of the study. The main research question was formulated as:

How does peer observation of teaching on the PCK of mathematics novice teachers in teaching Grade 11 statistics enhance the teaching of statistics in a circuit?
In the study the following sub-questions were answered:

(a) How does peer observation of teaching of novice teachers improve the teaching of grade 11 statistics?
(b) What activities favoured peer observation of teaching for improving novice teachers' PCK in teaching Grade 11 statistics?
(c) What was the nature of improvement on the mathematics novice teachers' PCK in teaching statistics?

In order to answer these questions, a specific aim (see Section 1.4) and objectives were set. The research questions were addressed by the literature review, pre-observation meeting with the novice teachers, classroom observations, pre-lesson and post-lesson semi-structured interviews and post-observation meeting with the

two mathematics novice teachers. Chapter 2 was dedicated to literature review which revealed the benefits and limitations of POT, an overview of the teaching and learning of statistics in the South African classroom, a summary of research studies conducted on the teaching and learning of statistics, an overview of theories of PCK and challenges faced by novice teachers. Chapter 3 discussed the research methodology used to collect data taking into consideration limitations and ethical issues involved. Chapter 4 discussed data presentation, analysis and discussion of findings obtained during the study.

5.3 Summary of the literature review

The aim of the study was to explore how peer observation of teaching on the PCK of mathematics novice teachers in teaching Grade 11 statistics enhances the teaching of statistics. The study helped explain what took place when South Africa introduced statistics into the mathematics curriculum of statistics and the nature of South African curriculum on statistics. This aspect was accomplished through conducting some extensive literature review (see Chapter 2). The literature reviewed looked at importance peer observation of teaching (Keith, 2007; Richards and Farrel 2005; Rowe *et al* 2010; Spiller, 2011 and Thúy, 2012) and its limitations (Bell and Cooper, 2013; Gosling, 2002 and Blackmore, 2005; Robinson, 2010).

Some of the aspects mentioned in the literature reviewed included studies carried on statistics in South Africa and other countries, challenges faced by teachers in the teaching and learning of statistics (Tishkovskaya and Lancaster, 2012; Makwakwa, 2012; Opolot-Okurut *et al*., 2008; Ben Zvi and Garfield, 2007; Batanero, Burrill and Reading, 2011). The literature reviewed brought to light that South African teacher preparation programmes inadequately prepared teachers to teach statistics (Wessels, 2008 and Wessels, 2011) and that there was shortage of teachers qualified to teach statistics in South Africa (Batanero, 2012 and Makwakwa, 2012). Some aspects of PCK as viewed by Shulman (1986) were discussed including how various researchers (Etkina, 2010; Davidowitz and Rollnick, 2011; Rollnick *et al*., 2008; Mavhunga and Rollnick, 2013 & Ball *et al*, 2008) described PCK.

Also reviewed was literature on challenges faced by novice teachers (Amoroso, 2005; Cobbold, 2007; Howe, 2006 & Street, 2004; Zakaria and Adnan, 2010 and

Wessels, 2008) when they join the teaching profession. Some of the researchers (Harris and Sass, 2008; Ladd, 2008) found that though novice teachers face challenges as they join the teaching fraternity, some of them can perform just like their experienced counterparts or even outperform them in approaching the teaching of statistics.

5.4 Summary of the research methodology

In order to answer research questions, a case study was used. This case study sought to explore how peer observation of teaching on the PCK of mathematics novice teachers in teaching Grade 11 statistics enhances the teaching of statistics in a certain circuit in Mpumalanga Province of South Africa. The research approach was qualitative and data collection was done within a case study design. The qualitative approach focused on the meaning of individual experiences wherein the researcher used semi-structured interviews and classroom observation to gather data from the mathematics novice teachers.

The sample of this study consisted of two mathematics novice teachers from a certain circuit in Mpumalanga Province. The selected circuit consisted of a population of five mathematics novice teachers from which two of them were selected. The two mathematics novice teachers were engaged in pre-observation meeting, classroom observations, pre-lesson and post-lesson semi-structured interviews, post-observation meeting discussions and reflections. Since the performance of learners in statistics in the national examinations in the Mpumalanga Province was not impressive and more mathematics novice teachers still continue to be recruited, this study might assist the Mpumalanga Department of Basic Education to implement strategies to support mathematics novice teachers and assist learners to perform better in statistics.

5.5 Summary of the findings of the study

The findings of this study provide the readers, educators and policy makers with the insights into how peer observation of teaching on the PCK of mathematics novice teachers in teaching Grade 11 statistics can enhance the teaching of statistics. The

analysis results and findings of this study are presented in Chapter 4. The following are the major findings:

5.5.1 Improvement of teaching of grade 11 statistics by mathematics novice teachers

The results reveal that the two mathematics novice teachers felt that the POT process was beneficial to them because it made them conscious of their strengths and weaknesses in the teaching of statistics. Moreover, the teachers acknowledged that POT gave them the opportunity to study teachers' guides, diagnostic reports, examination guidelines and the CAPS document which also gave them information on how to handle and deliver statistics lessons effectively. Those documents assisted them to prepare effective statistics lessons using suggestions in the CAPS documents and common learners' problems depicted in diagnostic reports. The two teachers also noted that they learnt about the importance of technology in a statistics classroom. The discovery of some conceptual errors in some textbooks made the teachers to interrogate and hunt for effective statistics textbooks and resources. Above all, general classroom management improved during the POT process.

5.5.2 Effectiveness of the POT process

According to researchers, POT is a reciprocal process in which teachers observe each other teaching guided by mutual respect and trust. The two participants learnt to trust one another and also learnt to accept other people's views and how to incorporate them in lesson planning and delivery. During the POT process, the two teachers involved in the study also shared ideas in general classroom management and other aspects involved in teaching such as time management and use of resources. The two mathematics novice teachers expressed that although the POT process was time-consuming for them, they would encourage their schools to implement it. The teachers were made aware of their strengths and weakness and were given time to reflect on how to improve their teaching approaches. The POT process also allowed the novice teachers to learn on how to make use of policy documents.

5.5.3 Nature of PCK improvement of mathematics novice teachers during the POT process

The two novice teachers acknowledged that their statistical content knowledge improved due to thorough statistical content study prior to each classroom observation. Although this study did not quantify the improvement in the novice teachers' content knowledge, during classroom observations, the two novice teachers demonstrated dominion over the statistical content especially during the last two observations. Teacher A and Teacher B showed that they were studying statistics content on a daily basis during the study thereby improving their statistical content knowledge by consulting as many resources as were available to them. The two teachers improved in explanation of definitions of key concepts thereby fostering learners' conceptual understanding.

During the preliminary classroom observations, the two novice teachers predominantly used the traditional method of portraying the teacher as the source of information. The situation began to change for each teacher during the study as learner-centred instructional strategies such as oral probing questioning and group work, among others, were introduced. Learner participation and involvement improved during the POT process because the instructional strategies introduced were learner-centred. The teachers moved from the position of providing solutions for learners to letting learners provide answers themselves and explaining their solutions on the chalkboard to the whole class.

It also became clear as the study progressed that, the two novice teachers embarked on encouraging learners to engage in class discussion, assisting learners with misconceptions and problems in the topic, marking learners' workbooks and asking the learners oral questions. When the POT process began, learners' workbooks were not thoroughly marked, but by the third classroom observations, all learners' workbooks were marked with highlights on errors committed. The teachers' interactions with the learners and openness allowed learners to expose their difficulties and misconceptions. This made the teachers' knowledge of learners' learning difficulties and misconceptions in statistics to improve. With regards to knowledge of learners' learning difficulties and misconception, there was some indication that the two mathematics novice teachers had improved their questioning

techniques. The teachers always solicited answers from learners and most of the time the learners would provide answers themselves. This clearly demonstrates some improvement in the teachers' knowledge of learners' difficulties. The teachers improved in the skill of identifying learners' errors and could explain to the learners more to eliminate errors and misconceptions.

During the POT process, the two novice teachers interacted more with learners during their last two lessons. Researchers (Rollnick et al (2008) and Hawkins (2012)) assert that interaction with students improves teachers' PCK because they are able to know each student and how each student thinks (Bukova-Güzel, 2010 and Etkina, 2010). The two teachers' use of a variety of instructional strategies also suggests improvement in PCK according to researchers (Ijeh (2012), Hawkins (2012), Shulman (1986).

5.6 Limitations of this study

The first limitation was that there was not enough time to conduct the study. Three weeks was a short time. The second limitation was organizing the lesson observations at three different schools. It was a challenge to convince principals to change their schools' time-tables to suit the study. Thirdly, although the two novice teachers were from the same area and had similar qualifications, they did not have exactly the same years of experience. One of the novice teachers had never taught statistics before and had only four months of experience whereas the other novice teacher once taught statistics the previous year. One of the novice teachers confessed that he never got support from his mentor during teaching practice whereas the other did receive more than enough support. The difference between the backgrounds of the two novice teachers might impact on the findings of the study. Also difference in classroom experience might impact on the findings since research (De Jong, 2010; Schneider and Plasman, 2011) suggests that PCK improves with classroom practice and experience. The other limitation was the reluctance of some other novice teachers and their principals to participate in this study. Some of the principals voiced out that they feared to be exposed to the Department of Basic Education even though the researcher pledged to ensure anonymity and confidentiality of the school involved in the study. Of the five novice mathematics teachers in the circuit under consideration, only two mathematics

novice teachers together with their principals agreed to participate in the study. Had all the five mathematics novice teachers agreed to participate in the study, it is envisaged that some different findings could have been obtained and different conclusions could have been drawn.

5.7 Conclusion

This study focused on the how peer observation of teaching on the PCK of mathematics novice teachers in teaching Grade 11 statistics enhances the teaching of statistics in a certain circuit in Mpumalanga Province, South Africa. The sample consisted of two mathematics novice teachers selected purposively from a population of five mathematics novice teachers. During the study, it was revealed that the two teachers never studied any modules on the methodology of teaching statistics and never had opportunities of teaching the topic at their teaching practices. It was concluded that the two mathematics novice teachers lacked PCK and experience to teach statistics at the beginning of the study. The study revealed that during the POT process the two teachers started using learner-centred instructional strategies like oral probing questioning and group work, among others. At the beginning of the POT process, the two teachers predominantly used the lecture method. This demonstrates that the two teachers' knowledge of instructional strategies was developing.

Also during the POT process, the two teachers conducted collaborative lesson planning in the company of the researcher. Many aspects of the lesson were looked at especially learners' prior knowledge and anticipated learners' difficulties. During the lessons, the teachers checked learners' work in order to identify difficulties encountered and the teachers would ask questions to allow learners to expose their difficulties. The two teachers tried as much as possible to assist the learners who had misconceptions and learning difficulties. This demonstrates that the two teachers' knowledge of learning difficulties was developing as a result of the POT process. During classroom observations, the novice teachers showed that they rigorously studied the content for grade 11 and levels above grade 11. They also verbally conceded to have accessed university books to enhance their statistical content knowledge.

In conclusion, it is my view that the PCK of the two mathematics novice teachers was enhanced during the POT process. According to Shulman (1986), PCK is composed of knowledge of subject matter, knowledge of instructional strategies and knowledge of learners' misconceptions and learners' learning difficulties. The study revealed that these aspects according to Shulman (1986) developed during POT. Therefore, it can be concluded that peer observation of teaching on mathematics novice teachers in the teaching of statistics enhances and develops their PCK.

5.8 Recommendations

The researcher suggests the following recommendations:

5.8.1 Recommendations to the Department of Basic Education

(i) Peer observation of teaching of mathematics novice teachers in the teaching of statistics should be implemented during the first five years after each novice teacher has graduated from college or university.

(ii) At least two mathematics novice teachers should be deployed to each school where there is an experienced mathematics teacher to allow peer observation of teaching to be implemented effectively.

(iii) The Department of Basic Education should ensure that mathematics novice teachers are not overloaded to allow them to prepare and have time to engage in POT.

5.8.2 Recommendations for further research

(i) A comprehensive research study using both quantitative and qualitative approaches should be conducted on a larger sample of mathematics novice teachers to quantify the extent to which POT impacts on the PCK of mathematics novice teachers in the teaching of statistics.

(ii) A study should be carried out on the impact of POT in the teaching of statistics on the performance of learners.

(iii) Studies on the effect of POT on PCK of teachers should be extended to other mathematics topics other than statistics.

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Appendix A

Letter to the teacher

Date:

Dear Teacher

I, **Justine Chidziva**, hereby invite you to take part in a research which is to be carried out on teachers of mathematics as they teach statistics in Grade 11. I am a student of the University of South Africa and the study is focused on improving the quality of teaching of statistics in Grade 11. The title of the research is: **PEER OBSERVATION ON THE PEDAGOGICAL CONTENT KNOWLEDGE OF GRADE 11 NOVICE TEACHERS TO ENHANCE THE TEACHING OF STATISTICS IN A CIRCUIT** and my proposal has been accepted by the university.

I am kindly requesting you to volunteer to participate and may you understand that you are not forced to take part in this research. During the study, your lessons on the topics of statistics will be observed. The people who will observe these lessons will be the researcher and another selected novice teacher from one of the neighbouring schools who will be introduced to you in due course. You will also be requested to travel to the schools of the researcher and the other novice teacher to conduct classroom observations in statistics. Your lessons will be video recorded for future use by the researcher. Also field notes and critiques will be written about each lesson. You will be required to prepare for lessons you are going to teach and pre-lesson and post-lesson interview will be carried out.

Videos recorded by the researcher will be kept safe in a password protected computer and all field notes will be under lock and key in a secure cupboard only accessible to the researcher. I guarantee that you will not be affected in any way if you agree to take part, you can also decide to stop at any time and if you do, you will be affected in any way. Should you have any clarity seeking questions you are free to ask the researcher. When the research report will be presented your name will not appear but a pseudonym will be used to ensure that your privacy and confidentiality are observed. Also the research report will be made available to you. I would be grateful if you do share with me your experiences.

Yours faithfully

Justine Chidziva

Cell:0787006917 Email:justgoneka@gmail.com

Supervisor: Professor ZMM Jojo (University of South Africa: Mathematics Education Department)

Telephone: +27124296627 email: jojozmm@unisa.ac.za

Declaration by participant

I ……(full names of participants) hereby confirm that I understand the contents of this document and the nature of the research project. I understand that I am at liberty to withdraw from the project at any time should I so desire.

Signature of participant ……Date

Signature of interviewer……..Date

Do you give me the permission to record the interview?

Signature of participant……. Date

Signature of witness ……..Date

APPENDIX B

Permission-Letter to Mpumalanga Department of Education

The Head of Department
Mpumalanga Department of Education
Private Bag X11341
Nelspruit
1200
Date:

Dear Sir/ Madam

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SOME OF YOUR SCHOOLS: MYSElF

The above matter bears reference,

1. I, **Justine Chidziva**, a Master of Education (Mathematics Education) with the University of South Africa, hereby request to conduct a research in some of your schools that will meet the requirements of the sampling technique that will be used in the study.

2. The title of my research study is: **PEER OBSERVATION ON THE PEDAGOGICAL CONTENT KNOWLEDGE OF GRADE 11 NOVICE TEACHERS TO ENHANCE THE TEACHING OF STATISTICS IN A CIRCUIT** and my proposal has been accepted by the university.

3. The study will use a qualitative design using a case where data will be collected from selected learners and teachers.

4. The ethics policy of the University of South Africa requires that I get permission from the Department of Education to be able conduct this research. This ethics policy also requires that all participants of this study be protected by keeping their identities anonymous and the information confidential.

5. The Department of Education will benefit from this study by getting information about ways to support newly qualified Mathematics teachers.

6. When the study has been completed, a copy of the report will be made available to the Department of Education.

7. I have attached a brief research proposal containing all the information required.

8. Hoping for a favourable response to my request.

Yours Faithfully,

Justine Chidziva

Cell:0787006917

Email:justgoneka@gmail.com

Supervisor: Professor ZMM Jojo (University of South Africa: Mathematics Education Department)

Telephone: +27124296627 email: jojozmm@unisa.ac.za

APPENDIX C

Permission-Letter to the principals

To The Principal

Date:

Dear Sir/ Madam,

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT YOUR SCHOOL: MYSELF

I, **Justine Chidziva** (Student Number 46591656), a Master of Education (Mathematics Education) student at the University of South Africa, wish to request to conduct a research with a teacher in your institution. The title of my research is: **PEER OBSERVATION ON THE PEDAGOGICAL CONTENT KNOWLEDGE OF GRADE 11 NOVICE TEACHERS TO ENHANCE THE TEACHING OF STATISTICS IN A CIRCUIT** and my proposal has been accepted by the university.

Your Mathematics teacher in grade 11, who happens to be a novice teacher, will be required to participate in peer observation in the teaching of Statistics in Grade 11. This will be followed by an interview as well as document analysis of books, learners' exercise books, lesson plans, diaries and other supporting documents. During the research, the people who are going to observe lessons will be the researcher and another novice teacher from the neighbouring school. I kindly ask that you assist in making arrangements with the novice teacher.

I intend to protect the anonymity and the confidentiality of the teacher and learners' responses. Their names and contact details will be kept in a separate file from any data that they supply. This will only be able to be linked to their data by me. In any publication emerging from this research, they will be referred to by pseudonyms. If for any reason they would like their real names to be used in the publications, they will need to make written request to me.

A brief summary of the findings will be available to the teacher once the research has been completed. The findings might also be presented at academic conferences and published in national and international academic journals.

Please be advised that the participation of your school in this research project is voluntary. Should you wish to withdraw at any stage, or withdraw any unprocessed data you have supplied, you are free to do so. Your decision to participate or not, or to withdraw, will be completely independent of your dealings with the University of South Africa.

There will be no financial incentives for participating in the research but findings will be made known to your teachers. The teachers may withdraw at any time if they feel like and data collected before withdrawal will not be used any further. The data collection instruments as well as consent forms to participate are herein attached for your attention.

If you are happy for your school to participate, please indicate that you have read and understood this information letter by signing the accompanying consent form and returning it to me.

Should you require any further information, do not hesitate to contact the researcher.

Yours faithfully,

Justine Chidziva

Cell:0787006917

Email:ljchidziva@yahoo.com or justgoneka@gmail.com

Supervisor: Professor ZMM Jojo (University of South Africa: Mathematics Education Department)

Telephone: +27124296627 email: jojozmm@unisa.ac.za

……
……**cut here**

Return consent slip

I……principal

of……..School do consent to the above in my institution.

……

……**cut here**

APPENDIX D

Letter to the guardians

Date:

Dear Parent/ Guardian

I, **Justine Chidziva**, am an educator at Mafemani Nxumalo High School. I am currently doing Master of Education (Mathematics Education) degree at the University of South Africa and conducting a research on the title: **PEER OBSERVATION ON THE PEDAGOGICAL CONTENT KNOWLEDGE OF GRADE 11 NOVICE TEACHERS TO ENHANCE THE TEACHING OF STATISTICS IN A CIRCUIT** and my proposal has been accepted by the university. Learners in Grade 11 have been selected and your child is one of them.

The purpose of the study is to explore the effect of peer observation on the pedagogical content knowledge of novice mathematics teachers in teaching Statistics in Grade ii in Dwarsloop Circuit. The study will help improve the quality of teaching and learning of Mathematics which ultimately benefits the learners. During the study your child's workbooks will be looked at and video recording of the lessons will also take place. All videos of the lessons in question will be stored in a password protected computer to ensure that no information is shared but will only be used by the researcher. Your child is not compelled to participate in this study and also should your child choose to participate he or she will be free to withdraw from the study at any time. In the event that you decide that your child will not be part of the study, the researcher will request your child to sit in a position where he or she will not be video recorded during lesson time. Your child will not be disadvantaged at all in the event that he or she will not be part of the study. He or she will attend the same lessons with others but the researcher will not have access to your child's workbook and your child will not appear on videos that will be recorded. There are no anticipated potential risks or discomforts associated with the study. If you have any questions which need clarity you are free to ask the researcher in any mode of communication suitable for you. To protect the autonomy of your child, pseudonym will be used to ensure confidentiality and privacy and the child is referred to as a

respondent. I therefore ask for permission from you as a guardian to work with your child in this study.

Yours faithfully

Justine Chidziva

Cell:0787006917

Email:ljchidziva@yahoo.com or justgoneka@gmail.com
Supervisor: Professor ZMM Jojo (University of South Africa: Mathematics Education Department)

Telephone: +27124296627 email: jojozmm@unisa.ac.za

……
……cut here

Return consent slip

I, _____ (full name of parent/guardian), give my permission for my child _____ (name of child) to be included in the research study. I have read and understood the letter addressed to me. I understand that my child's identity will not be made public. I have kept a copy of the letter.

_____ _____

Parent's/guardian's signature Researcher's signature

APPENDIX E

ASSENT FORM

Dear _____

I am doing a study on teaching Statistics to Grade 11 learners as part of my Master's degree at the University of South Africa. The school principal and the Department of Basic Education have given me permission to do this study at your school and I would like to invite you to be a very special part of it. I am doing this study so to find ways to assist your teachers to understand how you learn Statistics in Grade 11 and ultimately find ways to make you understand the topic Statistics. This will help you and many other learners at your school and other schools.

This letter is to explain to you what I would like you to do. You may take this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study. If there are parts of this letter you don't understand very well, you can ask your register teacher or any other adult to explain these to you. Your parents are also being sent a letter asking that they give permission for you to take part in this research. Please agree with your parents or guardians so that you are allowed to take part in the study.

If you are willing to participate, you will be involved in this research during your usual mathematics lessons for 2 weeks. During the two weeks of the research, two teachers (me and another teacher) will observe your teacher delivering lessons in Statistics and taking note of learners' participation. You will be requested to avail your workbooks for review by the researcher, and also the lessons will be video recorded. The videos from the lessons observed will be kept safe by the researcher in a password protected computer. Your identity will not be disclosed and you are guaranteed privacy and confidentiality. No potential risks or harm are anticipated during the study. Your participation in this study will be voluntary and you will be allowed to withdraw at any given time. When I finish this study, I will give your class a short talk about some of the helpful and interesting things I found out. It will not cost you or your parents anything.

If you decide to take part, please sign the form overleaf. If you have any other questions about this, you can talk to me or you can have your parent or another adult call me. Do not sign the form until you have all your questions answered and understand what I would like you to do and until your parents have granted you permission to do so.

Yours faithfully

Justine Chidziva

Cell: 0787006917

Email: ljchidziva@yahoo.com or justgoneka@gmail.com
Supervisor: Professor ZMM Jojo (University of South Africa: Mathematics Education Department)

Telephone: +27124296627 email: jojozmm@unisa.ac.za

Child assent form

I, _____ (full name of learner), agree to be included in the research study. I also agree that my workbooks be viewed and notes to be taken down from them and also that videos of lessons in which I will be involved be taken for further use in the study. I have read and understood the letter addressed to me. I understand that my identity will not be made public. I have kept a copy of the letter.

_____ _____

Learner's signature Researcher's signature

APPENDIX F

Pre-observation meeting with teachers

1. What qualification(s) do you have and how long did you study to obtain them?
2. In your qualification(s), did you study any modules of statistics?
3. If yes, are you confident and satisfied that the content you studied at college was enough to enable you to teach the statistics at high school level?
4. Apart from studying the content did you study any module(s) on the methodology on how to teach statistics at high school?
5. During teaching practice, did you teach the content on statistics? If you did, how many lessons did you teach and to which grade?
6. Do you think you got enough support from your mentors during teaching practice?
7. Were your lessons observed while on teaching practice?
8. Do you think you got enough constructive criticism to enable you to improve your teaching from your mentors and lecturers?
9. How long have you been teaching and have you ever taught statistics in Grade 11?
10. Have you ever attended workshops that focus on teacher development? If so did the workshops cover the teaching and learning of statistics?
11. What do you think schools should do to improve the performance of learners in statistics?”

APPENDIX G

Post-observation meeting with teachers

1. How did you feel being observed by a colleague?
2. How do you compare observation done by a colleague to that done by a supervisor or a mentor?
3. Do you think you benefitted during the course of this research?
4. What things went on well during the study?
5. What things did not go well and how can they be addressed?
6. Do you think you now have knowledge of content per grade after this study?
7. Which area in the Statistics teaching do you think you need special assistance?
8. Will you continue to seek out and conduct peer observations outside this study?
9. What things did you learn from observing colleagues teaching?
10. What areas of your teaching do you think are going to improve after being observed by a colleague?
11. What do you perceive as weaknesses in the method of peer observation?
12. How did the peer observation process affect your perception of your teaching?
13. What things do you think should be done to make peer observation effective?
14. What do you think your school should do to implement peer observation to improve the quality of teaching of statistics by new teachers like you?
15. What do you think schools should do to improve performance of learners in statistics?

APPENDIX H

Pre-lesson semi-structured interview schedule to teachers

1. What do you intend to achieve in the lesson that I will observe?

2. What prior Knowledge do you think learners have before this lesson?

3. What teaching strategies are you going to use in the lesson? May you explain why you choose these?

4. What key concepts are going to be learnt in the lesson?

5. Are you going to use examples in the lesson? If so, do you have any which are real-life examples?

6. Do you anticipate any learners' misconceptions and difficulties in the lesson?

7. How are you going to assist learners with misconceptions and difficulties in the lesson?

APPENDIX I

Post-lesson semi-structured interview schedule to teachers

1. Did the lesson proceed in the way you had planned it? Why?

2. Did the learners master the key concepts of the lesson? Explain.

3. Did you detect any specific learners' misconceptions that you had not anticipated and difficulties did during the lesson? If so, how did you address them?

4. Do you think your strategies were effective in the lesson?

5. During the lesson, did you feel confident and enthusiastic? Why?

6. Do you think your students learned all that you wanted them to learn in this session? What brings you to this conclusion?

7. What did you learn about student learning from this class?

8. What targets for improvement have you set yourself for this class, and are they realistic?

9. If you were to teach this lesson again tomorrow, what would you do differently, and why?

APPENDIX J

Lesson plan analysis tool

ITEMS TO BE CHECKED	OBSERVATION
1. Does the lesson plan indicate the objectives and aims of the lesson? 2. Are there any key concepts indicated in the plan? 3. Does the lesson preparation reflect concepts related to the topic under consideration? 4. Does the preparation indicate teaching strategies to be used in the lesson? 5. Does the lesson plan indicate examples to be used in the lesson to allow concepts to be understood? 6. In the lesson plan is there reflection of any anticipated difficulties and misconceptions of the learners? 7. Does the lesson plan indicate learners' prior knowledge? 8. Does the preparation mention any activities to be done in class by both the teacher and the learners? 9. Are there any, assessment strategies that indicated in the lesson plan that the teacher intends to use in the classroom?	

Appendix K

Peer Observation Protocol

Name of Teacher:_____ **Name of peer observer**_____

Grade Observed_____

Date_____**Subject**_____

Topic:

1. Was the teacher confident during the lesson? Explain

   _____

   _____

   _____

   _____

2. Did the teacher clearly explain the purpose of the class session and instructional activities?

   _____

   _____

   _____

3. Did the teacher use examples in class? If so, were they adequate?

   _____

   _____

   _____

4. What instructional strategies were used in class? Were they appropriate?

   _____

   _____

   _____

   _____

5. Did the instructional strategies allow adequate learner participation?

   _____

   _____

_____

_____

6. Did the teacher detect any learner difficulties and misconceptions?

_____

_____

_____

_____

7. Did the teacher demonstrate that he knew the content he/she was teaching?

_____

_____

_____

_____

8. Was there any assessment in the lesson? If so, was the assessment strategy appropriate for the lesson?

_____

_____

_____

_____

9. Did the teacher have effective classroom management skills?

APPENDIX L

Permission to conduct Research

education
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA

Building No. 5, Government Boulevard, Riverside Park, Mpumalanga Province
Private Bag X11341, Mbombela, 1200
Tel: 013 766 5552/5115, Toll Free Line: 0800 203 116

Litiko le Temfundvo, Umnyango we Fundo | Departement van Onderwys | Ndzawulo ya Dyondzo

Ms. J. Chidziva
University of South Africa (UNISA)
PRETORIA
0001

RE: APPLICATION TO CONDUCT RESEARCH: MS. J. CHIDZIVA

Your application to conduct research was received. The title of your study reads: "The effect of peer observation on pedagogical content knowledge of mathematics novice teachers in teaching statistics in grade 11 in Dwarsloop Circuit." I trust that the aims and the objectives of the study will benefit the whole department. Your request is approved subject to you observing the provisions of the departmental draft research policy which is attached. You are also requested to adhere to your University's research ethics as spelt out in your research ethics document.

In terms of the attached draft research policy data or any research activity can only be conducted after school hours as per appointment. You are also requested to share your findings with the relevant sections of the department so that we may consider implementing your findings if that will be in the best interest of the department. To this effect, your final approved research report (both soft and hard copy) should be submitted to the department so that your recommendations could be implemented. You may be required to prepare a presentation and present at the department's annual research dialogue.

For more information kindly liaise with the department's research unit @ 013 766 5476 or a.baloyi@education.mpu.gov.za.

The department wishes you well in this important project and pledges to give you the necessary support you may need.

pp
MRS MOC MHLABANE
HEAD OF DEPARTMENT
28 / 01 / 2016
DATE

MPUMALANGA
THE PLACE OF THE RISING SUN

APPENDIX M

Ethical Clearance Certificate

UNISA

COLLEGE OF EDUCATION RESEARCH ETHICS REVIEW COMMITTEE
16 September 2015

Ref #: **2015/09/16/46591656/02/MC**
Student #: Mr J Chidziva
Student Number #: 46591656

Dear Mr Chidziva

Decision: Ethics Approval

Researcher
Mr J Chidziva
Tel: +2778 700 6917
jichidziva@yahoo.com

Supervisor
Dr. T Nkambule
College of Education
Department of Mathematics Education
Tel: +2712 352 4150
nkambt@unisa.ac.za

Proposal: The effect of peer observation on pedagogical content knowledge of mathematics novice teachers in teaching statistics in grade 11 in Dwarsloop Circuit

Qualification: M Ed in Mathematics Education

Thank you for the application for research ethics clearance by the College of Education Research Ethics Review Committee for the above mentioned research. Final approval is granted for 2 years.

For full approval: *The application was reviewed in compliance with the Unisa Policy on Research Ethics by the College of Education Research Ethics Review Committee on 16 September 2015.*
The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the College of Education Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.*
3) *The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.*

Note:
The reference number **2015/09/16/46591656/02/MC** *should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the College of Education RERC.*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Kind regards,

Dr M Claassens
CHAIRPERSON: CEDU RERC
mcdtc@netactive.co.za

Prof VI McKay
ACTING EXECUTIVE DEAN

APPENDIX N

Turn it in Certificate

Turnitin Originality Report

Thesis by Justine Chidziva

From thesis (thesis)

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APPENDIX O

Editing Certificate

DR GIFT MHETA
PhD Linguistics

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17 Cromwell Road
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Durban
4001
2nd May, 2017

EDITING CERTIFICATE

Re: Justine Chidziva

I confirm that I have edited Justine Chidziva's Master's thesis titled, "Peer observation on the pedagogical content knowledge of grade 11 novice teachers to enhance the teaching of statistics in a circuit". I am a freelance editor specialising in proofreading and editing academic documents. My highest qualification is a PhD in Linguistics. Currently, I am the Writing Centre coordinator at Durban University of Technology.

Should you need anything clarified, please do not hesitate to contact me.

Yours sincerely,

Dr Gift Mheta