

# **EXPLORING THE PEDAGOGICAL CONTENT KNOWLEDGE OF FET MATHEMATICS TEACHERS**

By

**ORIPPA MAJEZA**

**218082374**

A dissertation submitted in partial fulfilment of the  
academic requirements for the degree of Masters in  
Education in Teacher Development Studies

SCHOOL OF EDUCATION  
UNIVERSITY OF KWAZULU-NATAL  
PIETERMARITZBURG

2020

## **ABSTRACT**

The purpose of this study was to explore the pedagogical content knowledge of Further Education and Training mathematics teachers at Grade 10 level. A sample of three teachers was purposively selected because they were all teaching Grade 10 mathematics and had at least three years' teaching experience. All the teachers were from the Harry Gwala District in KwaZulu-Natal, South Africa. The study was a qualitative study underpinned by the interpretivist paradigm. The research design was a case study. Data was collected using interviews, classroom observations which were videoed and video-stimulated recall interviews. The study used Ball, Thames & Phelps' (2008) framework of Mathematics for Teaching focusing on the components of Pedagogical Content Knowledge only (that is, Knowledge of Content and Students, Knowledge of Content and Teaching and Knowledge of Content and Curriculum). The results of the study show that the teachers mainly used the lecture method in their teaching of the box and whisker plot in statistics. The findings indicate that all three teachers displayed adequate knowledge of content and curriculum. They displayed knowledge of content and students, although it was limited especially in terms of how to address and correct learners' misconceptions. They did, however, show great awareness of the misconceptions they anticipated from the learners. The findings also show that the teachers displayed limited knowledge of content and teaching in respect of teaching strategies, where they all used the lecture method. In addition, the results indicate that the teachers' pedagogical decisions were sometimes informed by additional resources available to them besides their knowledge of content and students, knowledge of content and teaching and knowledge of content and curriculum. Recommendations are made for further studies and also that methodology workshops need to be done on problem solving.

# DECLARATION

Submitted in partial fulfilment of the requirements for the degree of Masters in Education, in the Graduate Programme in the College of Humanities, University of KwaZulu-Natal, Pietermaritzburg, South Africa.

I, Orippa Majeza, declare that:

1. The research report in this thesis is my original, except where otherwise indicated.
2. This thesis has not been submitted for any degree or examination at any other university.
3. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other researchers. Where other resources have been quoted, then:
4. This thesis does not contain text, graphics or tables copied and pasted from the internet, unless specifically acknowledged, and the source being detailed in the thesis and in the Reference sections.

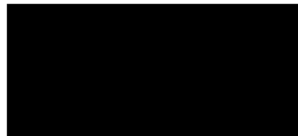
Orippa Majeza  
*Student Name*



*Signature*

20 October 2020  
*Date*

Professor Carol Bertram



*Signature*

20 October 2020

*Name of Supervisor*

*Date*

# DEDICATION

This dissertation is dedicated to my loving husband, Givemore Majeza, and my two sons, Titus Majeza and Kudzaishe Majeza, who have been there in support of me as pillars of strengths and encouragement.

# ACKNOWLEDGEMENTS

Firstly, I would like to give all thanks to God Almighty for giving me strength, courage and dedication to do this. I felt weak many times and wanted to give up, but through God's power I managed to go through to the end.

Secondly, I would like to give my heartfelt thanks and appreciation to the following people who have greatly contributed to this study. They supported me and gave me guidance.

1. Tendayi Mawango: Thank you very much for encouraging me to study and for being very supportive and guiding me. I am truly grateful.
2. Patience Mawango: Thank you very much for inspiring me. I followed your footsteps in studying and you encouraged me.
3. **Professor Carol Bertram: special thanks to you, Professor.** Only God can bless and thank you enough for me. I am so grateful. You were so patient and kind to me through this journey. You guided me and you continued to be patient even if I got confused many times. Thank you very much.
4. The KwaZulu-Natal Department of Education for granting me permission to conduct this study at their institutions.
5. Principals of schools 1, 2 and 3: thank you for giving me permission to conduct my study in your schools.
6. Participant teachers 1, 2 and 3: Thank you very much for participating willingly in my study. Without you I could not have done it.
7. My husband Givemore Majeza: Thank you for transporting me to Pietermaritzburg every Saturday throughout the year.
8. To my son Kudzaishe Majeza: Thank you for massaging me when I felt dizzy, fatigued and tired during my study and for staying with me till late hours to give me strength.
9. To my son Titus Majeza: Thank you for giving me words of encouragement when I felt like giving up.

## LIST OF ACRONYMS

AMESA	The Association for Mathematics Education of South Africa
ANA	Annual National Assessment
CAPS	Curriculum Assessment Policy Statement
CCK	Common Content Knowledge
DBE	Department of Basic Education
FET	Further Education and Training
GET	General Education and Training band
JIT	Just In Time
KCC	Knowledge of Content and Curriculum
KCS	Knowledge of Content and Students
KCT	Knowledge of Content and Teaching
MfT	Mathematics for Teaching
MKT	Mathematical Knowledge for teaching
NSC	National Senior Certificate
NSES	National Science Education Standards
PCK	Pedagogical Content Knowledge
SACMEQ	Southern and Eastern Consortium for Monitoring Quality
SCK	Subject Content Knowledge
SMK	Subject Matter Knowledge
SRI	Stimulated Recall Interviews
TIMSS	Trends in International Mathematics and Science Studies
GAISE	Guidelines for Assessment and Instruction in Statistics Education

# Contents

ABSTRACT.....	ii
DECLARATION .....	iii
DEDICATION .....	iv
LIST OF ACRONYMS.....	v
CHAPTER ONE: INTRODUCTION.....	1
1.1 Introduction .....	1
1.2 Focus and purpose of study .....	1
1.3 Rationale .....	1
1.4 Background information .....	3
1.5 Key Research Questions.....	6
1.6 Brief review of related literature and conceptual framework.....	6
1.6.1 Conceptual framework .....	7
1.7 Methodological approach.....	8
1.7.1 Sampling.....	9
1.7.2 Data collection .....	9
1.8 Ethical issues .....	10
1.9 Overview of the Dissertation .....	10
1.10 Conclusion.....	11
CHAPTER 2: LITERATURE REVIEW .....	12
2.1 Introduction .....	12
2.2 Teacher knowledge.....	12
2.3 Domains of teacher knowledge .....	13
2.3.1 Pedagogical Content Knowledge .....	14
2.3.2 Knowledge of instructional strategies .....	16
2.3.3 Knowledge of learners' understanding.....	17
2.3.4 Curricular knowledge.....	18
2.3.5 Conceptions of purposes for teaching subject matter .....	18

2.4 Mathematics knowledge for teaching (MKT) .....	18
2.4.1 Components of MKT .....	19
2.4.2 Knowledge of content and students (KCS) .....	20
2.4.3 Knowledge of content and teaching (KCT).....	21
2.4.4 Knowledge of content and curriculum (KCC).....	21
2.5 Statistical knowledge for teaching.....	22
2.6 International studies participated by South Africa on mathematics teacher knowledge .....	24
2.7 South African studies on mathematics teacher knowledge .....	25
2.7 Pedagogical decision-making.....	28
2.7.1 Importance of decision-making .....	29
2.8 Conclusion.....	30
CHAPTER 3: RESEARCH METHODOLOGY .....	31
3.1. Introduction .....	31
3.2. Research Paradigm .....	31
3.3. Methodological approach.....	32
3.4. Research design .....	33
3.4.1. Limitations to research design.....	33
3.4.2. Strengths of case study.....	34
3.4.3. Weaknesses of case study .....	34
3.5. Research context.....	34
3.6. Research sampling .....	35
3.7. Data collection methods .....	36
3.7.2 Interviews.....	37
3.7.3 Video-stimulated recall interviews .....	38
3.8. Data analysis .....	39
3.9. Trustworthiness .....	39
3.9.1 Role of researcher.....	40
3.10. Ethical considerations.....	40
3.11. Conclusion.....	41
CHAPTER 4: Presentation of the findings.....	42

4.1 Introduction .....	42
4.2 Analysis of data .....	42
4.3 Teacher biographies.....	42
4.3.1 Teacher 1 (T1) at School 1 (S1) .....	43
4.3.2 Teacher 2 (T2) at School 2 (S2) .....	44
4.3.3. Teacher 3 (T3) at School 3 (S3) .....	44
4.4 Box and whisker plots as a curriculum topic in Grade 10.....	45
4.4.1 Grade 10 statistics according to the CAPS curriculum .....	45
4.5 Lesson Observation of teacher 1 [school 1].....	46
4.5.1 Teacher 1: Description of lesson.....	46
4.5.2 Teacher 1: Lesson observation analysis.....	49
4.5.3 Teacher 1: Post-lesson interview analysis .....	52
4.6 Lesson observation of Teacher 2 [School 2] .....	53
4.6.1 Teacher 2: Description of lesson.....	53
4.6.2 Teacher 2: Lesson analysis .....	56
4.6.3 Teacher 2: Post-lesson interview analysis .....	59
4.7 Lesson observation of Teacher 3 [School 3] .....	60
4.7.1 Teacher 3: Description of lesson.....	60
4.7.2 Teacher 3: Lesson analysis .....	62
4.7.3 Teacher 3: Post-lesson interview analysis .....	63
4.8 Conclusion.....	65
CHAPTER 5: DISCUSSION OF FINDINGS AND RECOMMENDATIONS.....	66
5.1 Introduction .....	66
5.2 RQ1: What pedagogical content knowledge do FET teachers show in their teaching of mathematics? .....	66
5.2.1 Knowledge of content and students (KCS) .....	66
5.2.2 Knowledge of Content and Teaching (KCT).....	68
5.2.3 Knowledge of Content and Curriculum (KCC) .....	71
5.3 RQ 2: What is the relationship between the teacher’s pedagogic decision-making and their pedagogic content knowledge (PCK)? .....	72
5.4 Summary of findings .....	74

5.5 Limitations of the study .....	75
5.6 Recommendations .....	75
5.7 Conclusion .....	75
REFERENCES .....	77
APPENDIX 1: PERMISSION TO CONDUCT RESEARCH .....	85
APPENDIX 2: ETHICAL CLEARANCE.....	86
APPENDIX 3: LETTER SEEKING PERMISSION FROM THE SCHOOL PRINCIPAL.....	87
APPENDIX 4: LETTER TO PARTICIPANT.....	88
APPENDIX 5: LEARNER ASSENT .....	91
APPENDIX 6: PARENT CONSENT.....	93
APPENDIX 7: STRUCTURED OBSERVATION SCHEDULE .....	95
APPENDIX 8: SEMI-STRUCTURED INTERVIEW SCHEDULE FOR TEACHERS.....	97
APPENDIX 9: RESPONSES FROM T1, T2 AND T3 INTERVIEWS .....	98
APPENDIX 10: TURNITIN .....	101

<b>Table 1: Percentage of learners who achieved 30% level and above in the Grade 12 National Senior Certificate (2015-2019) (adapted from DBE NSC Reports).....</b>	<b>2</b>
<b>Table 2: Biographical details of participants .....</b>	<b>43</b>
<b>Table 3: Grade 10 statistics according to CAPS curriculum.....</b>	<b>45</b>
<b>Table 4: Lesson observation Teacher 1.....</b>	<b>47</b>
<b>Table 5: Lesson observation Teacher 2.....</b>	<b>53</b>
<b>Table 6: Lesson observation Teacher 3.....</b>	<b>60</b>
<b>Table 7: Instructional strategies and resources used by participants .....</b>	<b>71</b>

# **CHAPTER ONE: INTRODUCTION**

## **1.1 Introduction**

This chapter provides the focus and purpose of the study, as well as the rationale and background context. Teacher knowledge and pedagogical content knowledge (PCK) are defined according to various authors. The chapter presents the theoretical framework of PCK according to Ball, Thames & Phelps (2008). The methodological approaches are also discussed. The chapter concludes with a brief account of the main issues.

## **1.2 Focus and purpose of study**

The focus of my study is on teacher knowledge, in particular the pedagogical content knowledge (PCK) of three Grade 10 mathematics teachers in the Harry Gwala District, KwaZulu-Natal (KZN), South Africa. This study emerged from a concern about the general performance of learners in the rural areas. The achievement of learners in mathematics in the Harry Gwala District, one of 12 districts in KZN, has shown little improvement since 2015, as indicated by the Department of Basic Education (DBE), (See Table 1). Poor content knowledge of teachers, including poor PCK is a factor that contribute to learners' poor performance in mathematics (Adler & Venkat, 2012).

The purpose of the study was to explore the PCK of selected Further Education and Training (FET) Grade 10 mathematics teachers and to explore the relationship between the PCK of mathematics teachers and their pedagogic decisions. The study also aimed to develop an awareness of teacher knowledge so that the ways in which teacher development programmes are designed and delivered can be improved.

## **1.3 Rationale**

The study was motivated by my experience and concern as a mathematics teacher that the achievement of mathematics is deteriorating and does not show a significant improvement in my district, which consists mostly of rural schools. Although the schools are of different quintiles, they are all regarded as disadvantaged schools as they are located in a rural area. They were not chosen on the basis of their different

quintile status, they were selected due to their easy accessibility and convenience to the researcher. I have been teaching mathematics for many years but have observed poor results in most of the schools in my district, Harry Gwala, in KZN. Table 1 shows that the percentage pass rates in my district, Harry Gwala, are generally lower than the average provincial and national pass rates.

**Table 1: Percentage of learners who achieved 30% level and above in the Grade 12 National Senior Certificate (2015-2019) (adapted from DBE NSC Reports, 2015, 2016, 2017, 2018, 2019)**

	2015	2016	2017	2018	2019
Harry Gwala District	32.7	35.6	35.7	43.2	41.1
KZN province	33.2	37.9	41.6	50.6	48.5
National	49.1	51.1	51.9	58.0	54.6
S1 quintile 3	12	49	35	62.1	38.7
S2 quintile 2	41	43	49	60	60
S3 quintile 4	77	73	59	71.1	65

The study examines the PCK of teachers in the teaching of statistics, so it was also motivated by the fact that teacher training in statistics has not yet caught up with the needs of teaching the topic (Wessels, 2011). This might also be contributing to the poor mathematics results as teachers are not adequately trained to prepare learners in statistics. Statistical knowledge for teaching is important, as teachers must know how to help learners grasp the concepts of statistics. Statistical reasoning is also a crucial aspect in statistics because teachers need to understand and be able to explain processes in statistics to learners and to interpret the statistical results (Garfield & Chance, 2003).

The Department of Basic Education (DBE) has introduced many intervention strategies to try to address this issue of poor performance in mathematics, but with little success. This triggered my motivation to do this study to look at the pedagogical content knowledge of Grade 10 mathematics teachers. The different interventions which were put into effect by the Education Sector include “developing and providing learners and teachers with good quality textbooks, the 1+4 Intervention Model that advocates professional learning communities, and self-study guides, but (these) are

not changing the country's mathematics performance significantly." (DBE Report, 2017, p. 11).

Research suggests that the development of teacher knowledge in order to improve classroom instruction and learners' learning is a major problem in teaching (Abell, 2007). Teachers' poor content knowledge and poor pedagogical content knowledge has been identified as one of the causes underlying learners' poor mathematics achievement in South Africa (Adler & Venkat, 2012; Bansilal, Brijlall & Mkhwanazi, 2014). Studies to evaluate performance in mathematics have been done internationally, for instance, Trends in International Mathematics and Science Studies (TIMSS), Southern and locally, Eastern Consortium for Monitoring Quality (SACMEQ) and National Science Education Standards (NSES). According to Venkat and Spaul (2015), findings have shown that 79% of South African teachers teaching Grade 6 displayed content knowledge standards that were lower than Grade 6 and Grade 7 standards. Content knowledge standards are expectations that the teacher should be able to understand and demonstrate the content, its concepts and how to teach it so that they can help each learner to master the topic. Studies show that the teachers were not meeting those expectations. Taylor and Taylor (2013) assert that the continuing poor learner achievement has triggered motivation in comprehending how teachers' attributes, how they teach and their content knowledge may link to learners' poor academic development.

#### **1.4 Background information**

South Africa came out of apartheid and became a democratic country in 1994. Much educational research was done after the democratic elections. According to Venkat and Spaul (2015), the President's Education Initiative gave a directive that research should be done on different topics, including teacher content knowledge. Several studies indicate that PCK showed a higher connection with learner achievement than did content knowledge (Hill, Rowan & Ball, 2005).

Many educational changes took place after 1994; one of the biggest was in mathematics where some remarkable changes were made in the curriculum. One of the changes effected in the post-apartheid era was to ensure that all learners would be exposed to mathematics. Mathematics or mathematical literacy was made compulsory to ensure that all South African children are mathematically literate. In

2002 the National Curriculum Statements (NCS) (Grades 10-12) was implemented. Statistics was also introduced in mathematics in the General Education and Training (GET) phase. The official curriculum was reviewed again in 2012 and Curriculum Assessment Policy Statement (CAPS) was introduced. The CAPS curriculum aimed to redress the inequalities in the education of the past.

Various initiatives and interventions have been put in place since 1994 to improve the standard of education in South Africa, especially in mathematics (Bansilal, Brijlall & Mkhwanazi, 2014). The interventions include national and international studies such as the Trends in International Mathematics and Science Study (TIMSS). The interventions sought to address the low level of skills in mathematics that was revealed by these studies. Bansilal et al. (2014, p.1) contend that “many studies point to mathematics poor content knowledge as one of the reasons for low levels of learners’ mathematics achievement”.

The Department of Basic Education has also done professional development of teachers through content workshops, for example Just in Time (JIT), so as to develop teachers’ content knowledge of mathematics and methodology. Teachers would write pre-tests which revealed teacher’s poor content knowledge. This was identified as one of the reasons for learners’ low achievement in mathematics. The JIT workshops, the Association for Mathematics Education in South Africa (AMESA) and Siyavula (an educational technology company that aims to create high quality learning experiences in mathematics and science), have aimed at providing professional development in content in order to improve teacher knowledge.

A common finding relates to many South African mathematics teachers lacking fundamental understandings of mathematics (Venkat & Spaull, 2015). These findings are based on the results of summative assessments done nationally and internationally, such as the Annual National Assessment (ANA) and TIMSS, National Science Education Standards (NSES), Programme for International Student Assessment (PISA), Southern Africa Consortium for Monitoring Education Quality (SACMEQ), and the National Senior Certificate (NSC) examinations which were looking at learner performance.

Before 1994, the topic of statistics was not included in the South African school mathematics curriculum. After 1994, the scope of statistics was considerably

broadened “to promote statistical thinking through all phases of statistical process” in the new curriculum (Wessels, 2008). However, much work needs to be done in the teaching of statistics in South Africa so that teachers are ready to teach the expanded statistics curriculum and learners are educated statistically when they leave school (Wessels, 2008).

Wessels (2008, p. 21) adds that many teachers in South Africa are not fully empowered in teaching statistics because there is still “lack of content knowledge and knowledge of how learners develop and understand statistical concepts”. This means that the addition of statistics in the Mathematics curriculum in FET places some demands on teachers (Wessels, 2008). Mathematics teachers need to know how to develop learners’ literacy in statistical reasoning and thinking (Garfield & Ben-Zvi, 2005).

Scheaffer (2004) describes statistics as numbers in context, normally referred to as data. This shows the link between statistics and mathematics. Rumsey (2002) claims statistics in the mathematics curriculum raises awareness of data in everyday life. Statistics provides learners with useful knowledge to interpret the information in the world around them.

Teaching of statistics in South Africa involves the teaching of graphs, data collection, interpretation of information, measures of central tendencies, communication and discussion. Therefore, statistics must be taught in a way that aims to develop problem-solving and critical thinking. Lecturing methods have been the usual way of teaching statistics in South Africa, thereby narrowing learners’ participation (Wessels, 2008). Along the same lines, Wessels (2008) reports that many South African teachers do not have enough content and pedagogical content knowledge to teach statistics because the teachers have not had effective training in statistics.

This study is important as it aims at raising an awareness of the PCK of selected teachers, which may inform the Department of Basic Education about the PCK of teaching statistics. PCK is important for teachers because it combines knowledge of both the subject and of how teachers teach. The study may prove beneficial to the teacher participants as it gave them an opportunity to reflect on their classroom instruction so that they could think about how to improve it in future.

I conducted the study in three schools in the Harry Gwala District, which consists of 81 secondary schools. Some of the schools have big enrolments and some, small enrolments. My data collection methods were teacher interviews, class observation and post-lesson observation stimulated video-recall interviews methods. Each of the three teachers watched the video of their own teaching, and was asked about the reasons for their practices and which pedagogic actions they might want to improve in the future. I hoped that the study would help the three teachers because it provided them with feedback on their teaching. The findings might also be useful for conducting teacher development workshops in the district.

### **1.5 Key Research Questions**

1. What Pedagogical Content Knowledge (PCK) do Grade 10 teachers show in their teaching of Mathematics?
2. What is the relationship between PCK and teachers' pedagogic decision-making?

### **1.6 Brief review of related literature and conceptual framework**

In this section I provide definitions of teacher knowledge and pedagogical content knowledge. Secondly, I describe the domains of knowledge outlined by Shulman, followed by a review of the literature on PCK. More in-depth engagement with the literature will be provided in Chapter 2.

Morrow (2007) asserts that teacher knowledge is acquaintance with facts, information, the sum of what is known and being familiar with the topic. Shulman (1987, p. 127) and his colleagues describe seven domains of knowledge, "general pedagogic knowledge, knowledge of learners, knowledge of context, knowledge of purposes and value of curriculum, content knowledge, curricular knowledge and pedagogical content knowledge."

The study focused on PCK as the key to teacher knowledge because it allows teachers to facilitate learning for learners by using representations, clear explanations and examples. The study discusses approaches to teaching a particular mathematical concept and reveals the teachers' planning, classroom interactions and explanations. Ball et al. (2008) suggest that teachers not only require knowledge of their subject, they require knowledge of how to teach that subject as well.

PCK as a knowledge foundation for mathematics teachers is vital for productive teaching. This concept was introduced by Shulman in 1986. Shulman (1987, p. 127) describes it as “the blending of content and pedagogy into an understanding of how particular topics, problems or issues are organised, represented and adapted to the diverse interests and abilities of learners, and presented for instruction.” In the same way, Mishra and Koehler (2006, p.1027) view PCK as knowledge which “involves teaching of strategies that incorporate appropriate conceptual representations in order to address learner difficulties and misconceptions and to foster meaningful understandings”. Similarly, Shulman (1986) contends that PCK involves representations and illustrations used to make learners comprehend the topic during teaching. De Miranda (2008, p. 17) defines it as “the knowledge of three knowledge bases coming together to inform teacher practice, namely, subject matter content knowledge, pedagogical knowledge and knowledge of context.”

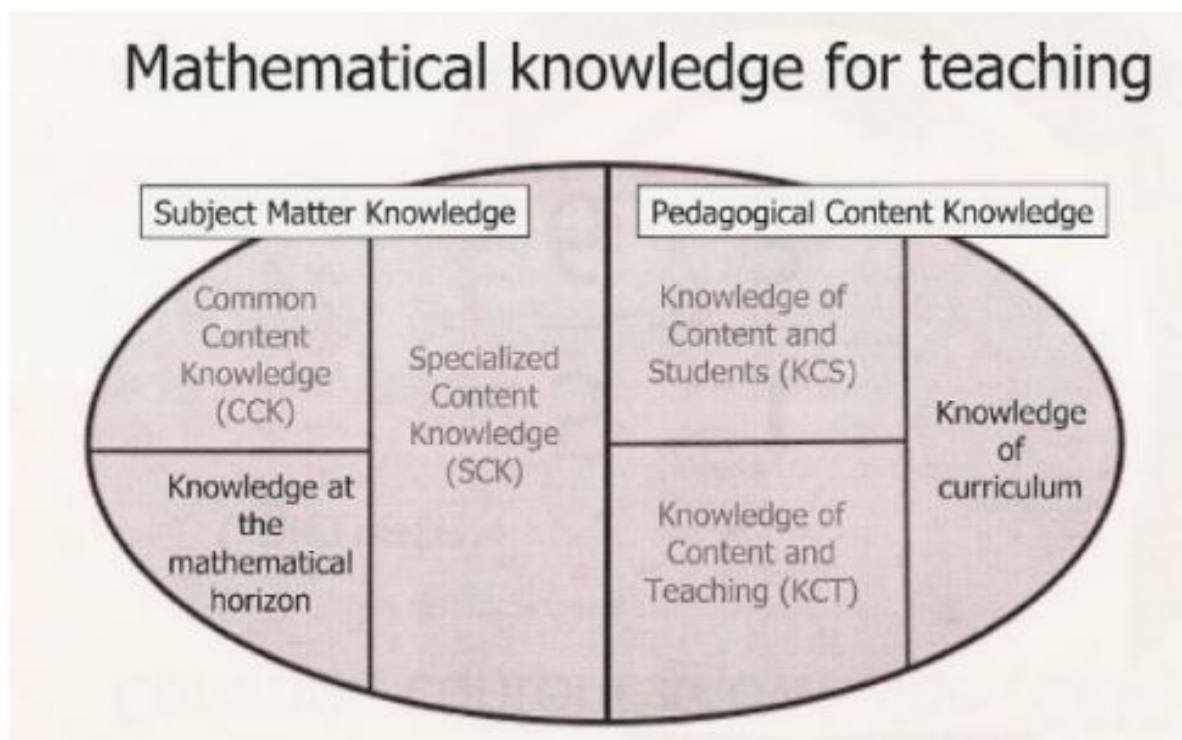
Grossman (1990) organizes the elements of the fundamental knowledge of teachers suggested by Shulman. Shulman (1986) argues that there is a disparity between content knowledge and general pedagogical knowledge of teachers. The teacher’s knowledge of content must have a sound comprehension of the concepts to be learnt by learners. However, there are relatively few studies of the PCK of mathematics teachers and it still requires more research.

Shulman (1987) identifies some elements of PCK which include knowledge of educational context, knowledge of learners, knowledge of educational ends, purposes and values and their philosophical and historical grounds. Shulman discusses the need for knowledge of learner thinking, knowledge of models that illustrate the key concepts and an understanding of what contributes to how easy or difficult concepts are to grasp.

### **1.6.1 Conceptual framework**

The conceptual framework for this study was based on the components of Pedagogical Content Knowledge according to Ball et al. (2008), who expands on Shulman’s (1986) notion of PCK to develop the model of mathematical knowledge for teaching (MKT). Figure 1 below shows the framework for Mathematical knowledge for teaching. This study will only focus on the PCK component, which will be further explained in the next chapter.

Figure 1. Framework for Pedagogical Content Knowledge (Ball et al, 2008)



### 1.7 Methodological approach

The study used a qualitative research approach based on the interpretivist paradigm. Brynard, Hanekom & Brynard (2014, p. 37) assert that “Qualitative methodology refers to the research that produces descriptive data – generally the participant’s own written or spoken words pertaining to their experience or perception.” I chose qualitative methodology because it enabled me to look at the world from the participants’ perspectives. Creswell (2009) also adds that it engages conversation with participants in a natural setting.

This study used an exploratory case study research design. I chose it because it gave me an in-depth insight into the way the teachers understood their subject content, how they presented it to learners for easy understanding and how they corrected misconceptions by learners. According to Robson (2002), as cited in Cohen, Manion & Morrison (2018, p. 375), case study research design involves “an individual case study; set of individual case studies; a social group study; studies of organisations and institutions; studies of events, roles and relationships.”

My case study was based on a sample of three Grade 10 mathematics teachers. The case study research design aimed to illustrate, examine and explain the differences between real individuals and situations through explanations and available reports. Cohen et al. (2018) argue that case studies represent reality and a sense of being there. Yin (2003) adds that a case study assists in finding answers to specific questions. Willis (2007) points out that it allows the researcher to collect more data with comprehensive information in a natural setting.

I chose a case study because it allowed me the use of various research methods, I could establish rapport with the participants, and I could acquire rich information (Merriam, 2009). A case study offers in-depth insight. "Case studies are strong in reality. A single researcher can undertake the case study. Case studies catch unique features that may be lost in a large-scale data (e.g. surveys). They can embrace and build in unanticipated events and controlled variables" (Cohen et al., 2018, p. 379).

### **1.7.1 Sampling**

In this study I employed purposive sampling and chose three Grade 10 teachers from three different schools according to their seniority and with experience of at least three years. Due to limited time I chose the schools on the basis of my convenience as researcher. The study took place in the Harry Gwala District, KwaZulu-Natal.

The first school is in a semi-rural area and comprises learners coming from poor economic backgrounds. There are approximately 800 learners in School 1 and the school is poorly resourced in terms of furniture, textbooks and buildings. It is a non-fee-paying school, which is categorised as a quintile 3 school. The second school comprises learners from low and middle-class backgrounds and it is located in a peri-urban area. It has a population of about 1 000 learners and is categorised as quintile 2. The resources in terms of furniture, buildings and textbooks are better than those in School 1. The third school comprises of learners from middle and upper socio-economic backgrounds. It is a well-resourced school with approximately 1 200 learners. It is categorised as a quintile 4 school. The school has enough furniture, good buildings, textbooks and computers for learners.

### **1.7.2 Data collection**

This study used observation of classroom lessons which were video recorded, interviews and post-lesson video-stimulated recall interviews so as to generate data

in the classroom on how the teachers taught, the strategies they used, and how they helped learners to understand some concepts which were misinterpreted. I chose observation because it enabled me to observe the sequence of the lesson, how the teachers selected examples to develop learners' better understanding of the concepts and how the teachers chose suitable strategies and representations to illustrate the content. Observation schedules were used as the data collecting instruments.

The video-stimulated recall interviews entailed the teachers watching the video of their practice, observing what happened when they were teaching and reflecting on their actions. The videos supported reflection of the teachers' mathematical practices. The study used semi-structured interviews, which allowed me to probe and get clarity from the respondents. Semi-structured interviews also helped me to establish rapport with the participants and get first-hand information from them. The semi-structured interview helped me to find out how the teachers acquired the knowledge that they have and if the teacher development workshops would improve their PCK.

## **1.8 Ethical issues**

Bertram and Christiansen (2014, p. 65) contend that "ethics has to do with behaviour that is considered right or wrong..." I obtained ethical clearance from the Department of Basic Education and from the UKZN Ethics Committee to conduct the research. I wrote a letter to get informed consent from the principals of the schools concerned and from the teachers.

Trustworthiness was established by respecting the autonomy of the participants. I assured the participants that no harm would be done to them. I guaranteed their privacy, confidentiality and anonymity. I also established credibility by assuring them that the findings would be confirmed by someone else like the supervisor, or by means of member-checking. Lastly, I will provide the findings of the research to the participants by conducting a workshop to give feedback of the findings.

## **1.9 Overview of the Dissertation**

Chapter 1 has presented an introduction to the study, focus and purpose of the study, rationale, background, research questions and a brief review of literature and conceptual framework.

Chapter 2 provides literature on PCK by reviewing the literature on PCK according to Shulman and other authors, and also looks at components of PCK using Ball et al.'s (2008) framework of Mathematical Knowledge for Teaching.

Chapter 3 presents the methodology of the study. It describes the paradigm, research design, strengths and weaknesses of case study, sampling, data collection methods and ethical issues.

Chapter 4 provides the findings of the study. The participants' teaching is evaluated based on data collected from the observations and interviews.

Chapter 5 summarises the results of the study. Findings are interpreted and recommendations given for future research. The chapter also compares the similarities and differences in the PCK of the three teachers in terms of KCS, KCT and KCC. Lastly, recommendations for further studies on the issue are offered.

## **1.10 Conclusion**

This chapter provided an introduction and background of the study. It highlighted the research problem and presented the rationale and significance of the study linking to teacher knowledge. The research questions of the study were stated. A summary of the literature review was also provided. The theoretical framework according to Ball et al (2008) was included as well as the research methodology. The next chapter presents a detailed literature review on PCK.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

This chapter discusses the literature needed to justify the study, which sought to explore the PCK of Further Education and Training (FET) teachers in order to have a clear picture of their understanding of the teaching of mathematics. It also sought to explore the relationship between PCK and the teachers' pedagogical actions in their teaching of mathematics. This chapter highlights domains of teacher knowledge, specifically looking at the concept of pedagogical content knowledge (PCK) which is the focus of the study. Teacher beliefs about the nature of mathematics and pedagogical choices are also discussed in this chapter

## 2.2 Teacher knowledge

One component of professionalism in teachers is teacher knowledge. Shulman (1986) was the first researcher to describe the knowledge base for teachers (Bertram, 2011). Teachers play a very important part and have an effect on learners' understanding, so teacher knowledge has become an issue for concern and a focus of interest to educators and policy makers, according to Shulman (1986). It is important to understand teacher knowledge because it can influence the performance of learners and may generate new ideas for achieving educational success.

Shulman (1987) defines teacher knowledge as all the knowledge applied to teaching. Researchers view it as "a body of professional knowledge that encompasses ... knowledge of subject matter to be taught" (Grossman, 1988, p.9). It plays a big role in decision-making for effective teaching according to Grossman (1990). In addition, Ball et al. (2008, p. 399) assert that knowledge includes "skill, habits of mind and insight". Teacher knowledge also links to curriculum content, materials and the particular content required for a given grade.

Teacher knowledge refers to the teacher being knowledgeable of a circumstance or fact that is gained through experience, reading books, media and encyclopaedias and from academic institutions and other sources. Teachers gain knowledge from reading research based in practice and improve their knowledge through experience, observation and reflection on classroom practices.

Hill, Ball & Schilling (2008) contend that many teachers do not have faith in themselves and their own content knowledge when teaching mathematics. Ball et al. (2005) assert that teachers need a deep understanding of mathematical concepts in order to have a variety of strategies for explaining and representing mathematical content to their learners. Brijlall (2014) states that teachers should know why a concept is as it is, and not just know the concept. Mathematics teachers need to know their learners' thinking and the ideas underlying that thinking (Krauss, Baumert & Blum, 2008). PCK also means that teachers need to know how these ideas can best be explained so that learners can understand them (Shulman, 1986).

There are various categories of teacher knowledge according to various researchers. This study looked at Shulman (1986, 1987), Grossman (1990) and Ball et al.'s (2008) domains of knowledge. The focus of the study was on pedagogical content knowledge, hence other domains have only been outlined, not examined in detail.

### **2.3 Domains of teacher knowledge**

Shulman (1986) asserts that there are seven types of basic knowledge that a teacher must have. Shulman (1986, p. 8) identified seven domains of teacher knowledge:

general pedagogic knowledge, subject matter knowledge, content knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts and knowledge of educational ends and knowledge of purposes, educational purposes and educational values and their philosophical and historical grounds.

Shulman (1986, p. 9) raised questions about teacher knowledge:

what kinds of knowledge do teachers use as they reason? Where do teacher explanations come from? How do teachers know what to teach and how do they represent it? How do teachers question learners about what they want to teach? How do they deal with problems of misunderstanding?

Shulman (1986) and his colleagues identified a type of knowledge called pedagogical content knowledge and have played a big role in trying to understand what this domain of knowledge involves.

Grossman (1990) was the first to build on Shulman's work and identified four categories of teacher knowledge, that is, subject matter knowledge, pedagogical content knowledge, general pedagogical knowledge and knowledge of context.

Subject matter knowledge (SMK) focuses on content knowledge of subject and knowledge of the substantive and syntactic structures of the discipline according to Schwab (1964, cited in Grossman, 1990). SMK includes an important component of the knowledge fundamentals of teaching (Grossman, 1990). Grossman (1990) also identified general pedagogical knowledge (GPK) which includes basic knowledge, beliefs and the skills linked to teaching, as well as beliefs which concern learning and learners. The third domain, according to Grossman (1990), is knowledge of context (KC) in which teachers adapt their knowledge to specific school settings and individual learners. Lampert (1984), as cited in Grossman (1990), contends that teacher knowledge to be used in the classroom must be context-specific. This means that the knowledge of the teacher must be adapted to suit the specific learners and their district, their community, school culture, learners' backgrounds, families and other contextual factors. Grossman (1990)'s fourth domain of knowledge is pedagogical content knowledge (PCK), which is the focus of this study. PCK in mathematics is much more than simple knowledge of mathematics (Grossman, 1990).

### **2.3.1 Pedagogical Content Knowledge**

Pedagogical content knowledge is an important knowledge base for Mathematics teachers for effective teaching (Shulman, 1987). This domain of knowledge goes beyond knowing the subject. This implies that teachers must have PCK besides other bases of knowledge. Kind (2009) asserts that PCK is a type of knowledge that teachers display when teaching.

The concept of PCK was first introduced by Shulman (1986), who argues that there is a lack of balance between the content knowledge and the general pedagogical knowledge of teachers. Shulman (1987) contends that PCK is the special combination of content knowledge and pedagogy. Within PCK Shulman (1986, p. 9) includes "illustrations, examples, explanations and demonstrations." Lowery (2002, p. 69), as cited in Ball et al (2008), defines PCK as "that domain of teachers' knowledge that combines subject matter knowledge and knowledge of pedagogy". Shulman (1986) argues that the teacher's knowledge of content must include a thorough understanding of the concepts that learners need to understand.

Shulman (1986, p. 9) defines PCK as "the most useful forms of representations of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations..." PCK involves representations and illustrations used to make

learners understand the topic during teaching. Similarly, Mishra and Koehler (2006, p. 1027) contend that it “involves teaching of strategies that incorporate appropriate conceptual representations in order to address learner difficulties and misconceptions and to foster meaningful understandings”.

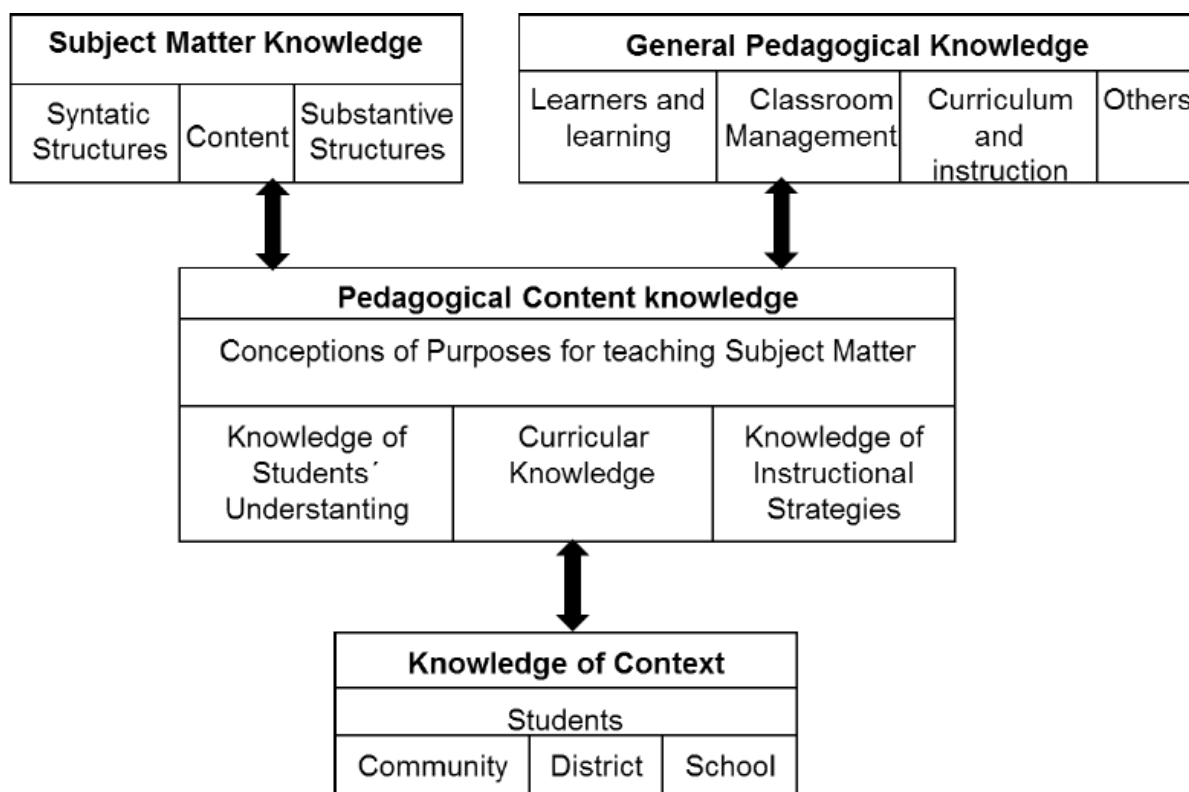
Shulman (1987, p.8) emphasizes three teacher knowledge issues, that is, content, pedagogy and learners. Pedagogic content knowledge is knowledge of teaching strategies and suggests how to organise, represent and adapt the subject taught (Shulman, 1987). This implies that teachers must use their knowledge of subject matter to select appropriate topics, and their knowledge of learners’ prior knowledge and conception in order to plan appropriate representations of the content learners need to learn.

PCK involves having knowledge of how to take advantage of various teaching strategies so that learning experiences become worthwhile for learners (De Miranda, 2008). Similarly, Shulman (1986a as cited in Grossman 1990, p.7) suggests that PCK “includes an understanding of what makes the learning of specific topics easy or difficult ...”

PCK is very important in understanding the factors that contribute to better teaching behaviours. All the definitions above show that PCK is the changing of subject matter to what learners are capable of learning, thus bringing up an understanding of what is a difficult or easy topic.

Grossman (1990) asserts that pedagogical content knowledge is one of four components of teacher knowledge that are important for teaching.

**Figure 2. Grossman (1990) Domains of teacher knowledge**



### 2.3.2 Knowledge of instructional strategies

Instructional strategies knowledge is teachers’ knowledge of the methods they may use to help the learners better understand the concept being taught. The PCK of teachers “involves knowing how to take advantage of different teaching approaches that make a learning experience most appropriate for the learners” (De Miranda, 2008, p.17).

Hoadley and Jansen (2012) contend that the Curriculum Assessment Policy Statement (CAPS) document does not tell teachers how they must teach. The CAPS document describes and gives an outline of certain content to be taught, at what specific time and the extent to which the content should be assessed. It aims at providing a more robust approach and gives more information on what content to teach and assess for every subject at each grade level. The CAPS curriculum is more content oriented, according to Ramatlapana and Makonye (2012). This means that the

teacher must make appropriate choices of teaching strategies and also understand that different lessons need different teaching methods.

Shulman (1987) states that the correct choice of instructional strategies depends on the teacher's knowledge of available strategies, as well as the teacher's knowledge of his learners. Teachers with a good knowledge of PCK are able to choose teaching strategies that are necessary for the development of the learners. The CAPS curriculum encourages an active and critical approach to learning, rather than learning by memorising. This implies that a successful strategy of instruction is one that highly involves the learner (Eysink, de Jong, Berthold, Kolloffel, Opfermann & Wouters, 2009).

### **2.3.3 Knowledge of learners' understanding**

Brodie (2014) refers to misconceptions as the result of learners trying to construct their own knowledge but from an incorrect base of knowledge or incomplete prior knowledge. This implies that the teacher needs to diagnose learner misconceptions and find ways to assist learners to change and correct their prior knowledge. Shulman (1986) states that PCK involves conceptions and preconceptions that learners coming from different backgrounds bring to class. PCK involves the knowledge of ways to deal with those preconceptions if they are misconceptions. Similarly, Olivier (1989) believes that if teachers comprehend how learning occurs in mathematics they can be able to predict the misconceptions of the learners, explain how and why the learners think that way and help to correct those misconceptions.

This means that the teacher must know what learners already know about a topic so as to generate the correct explanations. When teaching exponents, for example, it is important for the teacher to know the misconceptions of learners; such as the misconception  $5^3$  means  $5 \times 3$  according to the learners, yet it means  $5 \times 5 \times 5$ .

Krauss et al. (2008) also defined knowledge of learners' thinking and assessment of their understanding as an aspect of teacher knowledge. Teachers should know the prior knowledge, misconceptions and errors of learners. Errors and misconceptions provide teachers with a reflection and knowledge of building learner understanding. An, Kulm and Wu (2004) add that the knowledge of learners involves the teacher's perception of their prior knowledge when learning a topic; the conceptual knowledge gained; ways of learning, and knowledge of the difficulties and misconceptions

experienced while a topic is being learned. This shows that the PCK of the teacher is important for them to understand the learners and determine their level of knowledge.

#### **2.3.4 Curricular knowledge**

Grossman (1990) asserts that curricular knowledge includes the knowledge of curriculum materials which are there for teaching a certain topic. Curricular knowledge reflects a teacher's broader knowledge of how topics are relevant to others within the same subject matter but beyond the grade level, and how they can be integrated to topics beyond mathematics. In South Africa, this would refer to how well a teacher knows the CAPS curriculum for all the grades of high school, and not just for the grades that she teaches.

#### **2.3.5 Conceptions of purposes for teaching subject matter**

Subject matter knowledge is a very important component of teacher knowledge as it influences the actual teaching (Ball et al., 2008). According to Grossman (1990, p.18), it may "contribute most significantly to conceptions of teaching school subjects, while the apprenticeship of observation may be the source of knowledge of instructional strategies and student understanding". The conceptions of teaching a subject are revealed in a teacher's goals for teaching particular subject matter (Grossman, 1990). For example, two teachers might have different perspectives on the purpose of teaching a certain topic or subject matter. The goals of a teacher for teaching a particular subject are not as well understood by learners as are their instructional strategies and choices of other curriculum materials.

### **2.4 Mathematics knowledge for teaching (MKT)**

Ball et al. (2008) used Shulman's (1986) teacher knowledge PCK underpinnings to introduce mathematics knowledge for teaching (MKT). The MKT defines various sub-domains within Shulman's (1987) and Grossman's (1990) PCK and subject matter knowledge (SMK) components. PCK is divided into three categories namely KCS, knowledge of content and teaching (KCT) and knowledge of content and curriculum (KCC) whereas SMK is divided into common content knowledge (CCK), subject content knowledge (SCK) and knowledge at the mathematical horizon. However, only PCK components will be focused on as the study is exploring teachers' PCK.

Ball et al. (2008, p.395) define MKT as "the mathematical knowledge needed to carry out the work of teaching mathematics". It is "the mathematical knowledge needed to

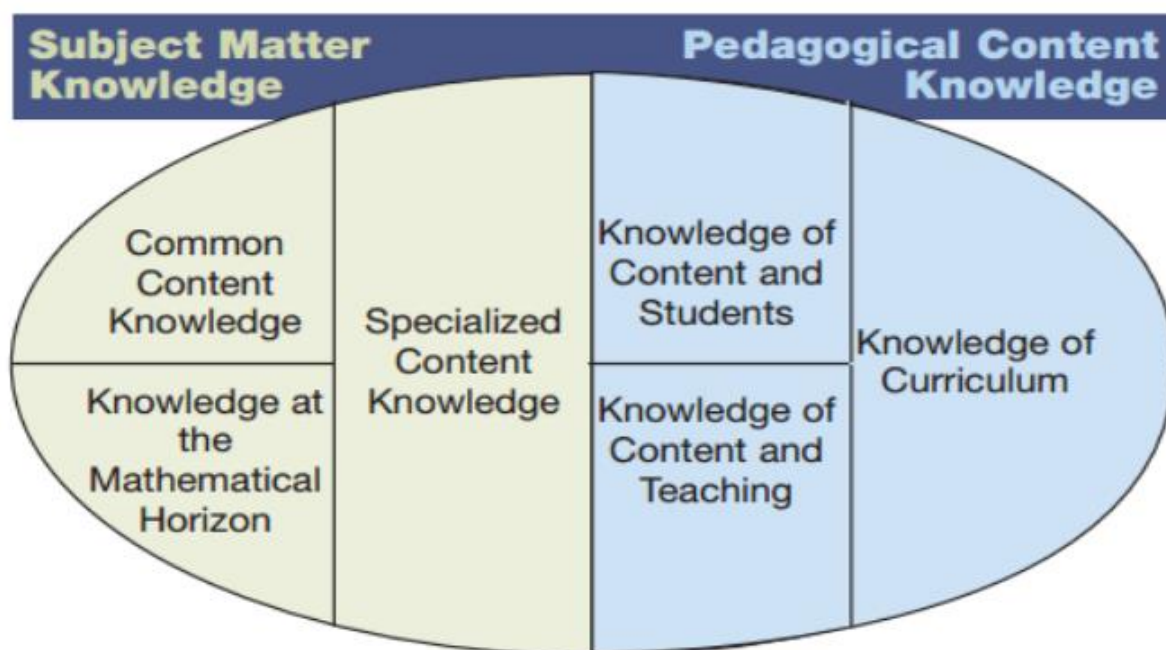
perform the recurrent task of teaching mathematics to students” (Ball et al. 2008, p. 399). Similarly, Thames, Sleep, Bass & Ball (2008) define MKT as a practice-based theory that shows the mathematics knowledge required to do the recurrent tasks of teaching mathematics. Kazima et al. (2008, p. 284) define knowledge of mathematics for teaching as “specialised mathematical knowledge that teachers (need to) know and know to use in their teaching.”

Ball et al.’s (2008) knowledge of content and students (KCS) concurs with Shulman’s knowledge of learners’ misconceptions and Grossman’s (1990) knowledge of students’ understanding, while knowledge of content and teaching (KCT) is similar to Shulman’s knowledge of educational representations and also links with Grossman’s (1990) knowledge of instructional strategies. Ball et al. (2008) share the same notion of knowledge of curriculum as Shulman and Grossman. These components will be explained in the following sections.

#### **2.4.1 Components of MKT**

Ball’s framework of MKT consists of six domains grouped into two general knowledge bases, subject matter knowledge (SMK) and pedagogical content knowledge (PCK) (see Figure 3). SMK includes common content knowledge, knowledge at the mathematical horizon and specialised content knowledge. PCK involves knowledge of content and students, knowledge of content and teaching and knowledge of curriculum. Only the literature on PCK will be discussed in detail, since this study focuses on PCK.

**Figure 3. Mathematical knowledge for teaching (Ball et al., 2008)**



Ball, Thames and Phelps (2008) built on Shulman’s PCK by identifying three knowledge categories. They categorised PCK into knowledge of content and students (KCS), knowledge of content and teaching (KCT) and knowledge of content and curriculum (KCC). These three categories are explained further below.

#### **2.4.2 Knowledge of content and students (KCS)**

Ball et al. (2008) assert that this is the knowledge that integrates knowing about learners and knowing about mathematics. It involves knowing concepts that learners will find easy or difficult and their conceptions and misconceptions. KCS concurs with Shulman’s knowledge of learner conceptions. Similarly, Hill et al. (2008) assert that KCS is content knowledge combined with knowledge of learner thinking.

Ball et al. (2008, p. 40) contend that KCS enables teachers to “anticipate what students are likely to think and what they will find confusing”. Teachers must be able to foresee what the learners are likely to think. Teaching will be easier if teachers know the origins of those mistakes and it will assist them to plan their lessons in a way that assists learners to correct those misconceptions. This knowledge allows teachers to deliver lessons in a way that helps learners to understand. In planning a mathematics lesson, teachers must be able to select and decide the sequencing of examples and performance tasks that would allow the learners to understand the topic.

Krauss et al. (2008) assert that knowledge of learners' thinking and assessment of their understanding is an important aspect because teachers should know the prior knowledge, misconceptions and errors of learners. Errors and misconceptions provide insight and provide teachers with knowledge of how to build learner understanding.

PCK includes an understanding of what conceptions and preconceptions learners of various levels and backgrounds have and bring with them in the learning process. This means that a teacher needs to know what learners already know about a topic so as to generate the correct explanations and have knowledge of the strategies to help re-organise learners' understanding.

#### **2.4.3 Knowledge of content and teaching (KCT)**

KCT is the knowledge of mathematics and of knowing how to teach. Brijlall et al. (2011) assert that there is a strong connection between content knowledge and knowing how to teach it. Teachers should know how to sequence examples and content for instruction and how to use appropriate representation. KCT allows teachers to decide what to do about misconceptions. They should know how to sequence examples, representations, and strategies to teach effectively. KCT helps teachers to use their mathematical and pedagogical knowledge to choose tasks that would affect learner learning positively. KCT resembles Shulman's knowledge of educational representations. The KCT of a teacher shows in how well the teacher can plan mathematics lessons, decide on the sequencing of examples and decide what would assist learners to understand the topic. This implies that a teacher with greater capability in KCT would already know the level of difficulty a mathematical problem has and what example may help prepare the class for the rigor demanded by the problem.

#### **2.4.4 Knowledge of content and curriculum (KCC)**

Knowledge of curriculum is the knowledge of available materials used to support learner learning and assess the mathematical quality of instructional materials. It is the knowledge of educational assessments, and the sequencing of topics across grade levels. This concept is not described clearly in Ball et al. (2008). This knowledge reflects on a teacher's knowledge of how topics link to other topics within the same subject matter and beyond mathematics. Knowledge of curriculum reveals a teacher's knowledge of programs designed for the teaching of particular subjects and topics at a certain level. This involves the materials available for instruction, for example,

textbooks with respect to those programs. The teacher needs to know what materials there are for teaching and learning and how to use these materials in an effective way.

## **2.5 Statistical knowledge for teaching**

The study focuses on teacher knowledge and it is also important to look at statistical knowledge for teaching and statistical reasoning since the teachers will be observed teaching statistics. After 1994, the scope of statistics was considerably broadened “to promote statistical thinking through all phases of statistical process” in the new curriculum (Wessels, 2008). It is a major aim in statistics to help learners develop statistical thinking, Franklin et al (2007). Garfield & Chance (2003) assert that statistical thinking “involves an understanding of why and how statistical investigations are conducted and the ‘big ideas’ that underlie statistical investigations.” Teachers must learn how to make others understand statistics, Groth (2017). Pfannkuch & Ben-Zvi (2011, p. 376) contend that teachers must “develop professional knowledge beyond statistical subject matter, e.g, they must learn to assess students’ reasoning and select tasks suitable for advancing students’ learning.”

Statistical thinking and reasoning links to Ball et al.’s (2008) Mathematics for Teaching model PCK components, KCS, KCT and KCC. “Knowledge of content and learners provides teachers with insight of how learners think about the discipline at hand, which allows the teacher to anticipate learners’ thinking. Knowledge of content and teaching provides instructional strategies for making specific concepts understandable. Knowledge of curriculum enables teachers to sequence lessons and tasks in the way that supports students’ learning” (Groth, 2017, p. 377).

Statistics in South African mathematics curriculum used to be limited to tasks whereby learners were required to work on small organised data sets and present them in graphs and answer simple questions which were direct. Formulas to find mean, median and mode were just prescribed without the teachers and the learners understanding the use and appropriateness of measures of central tendency (Wessels, 2008). North & Zewotir (2006) add that this formula-based approach resulted in learners who were not well prepared for statistics at tertiary level. Much work needs to be done in the teaching of statistics in South Africa so that teachers are ready to teach the expanded statistics curriculum and learners are educated statistically when they leave school (Wessels, 2008).

Wessels (2008, p. 21) adds that many teachers in South Africa are not fully empowered in teaching statistics because there is still “lack of content knowledge and knowledge of how learners develop and understand statistical concepts”. This means that the addition of statistics in the Mathematics curriculum in FET places some demands on teachers (Wessels, 2008). Mathematics teachers need to know how to develop learners’ literacy in statistical reasoning and thinking (Garfield & Ben-Zvi, 2005).

Scheaffer (2004) describes statistics as numbers in context, normally referred to as data. This shows the link between statistics and mathematics. Rumsey (2002) claims statistics in the mathematics curriculum raises awareness of data in everyday life. Statistics provides learners with useful knowledge to interpret the information in the world around them.

Teaching of statistics in South Africa involves the teaching of graphs, data collection, interpretation of information, measures of central tendencies, communication and discussion. Therefore, statistics must be taught in a way that aims to develop problem-solving and critical thinking. Lecturing methods have been the usual way of teaching statistics in South Africa, thereby narrowing learners’ participation (Wessels, 2008). Along the same lines, Wessels (2008) reports that many South African teachers do not have enough content and pedagogical content knowledge to teach statistics because the teachers have not had effective training in statistics. Garfield & Everson (2009) contend that the programmes that prepare statistics teachers must be in line with the current guidelines for teaching statistics at K-12 and college level, approved by the American Statistical Association.

The Guidelines for Assessment and Instruction (GAISE) project recommended the following to enhance and encourage teachers in the teaching of statistics, “1) emphasise statistical literacy and develop thinking; 2) use real data; 3) stress conceptual understanding rather than mere knowledge of procedures; 4) foster active learning in classroom; 5) use technology for developing conceptual understanding and analysing data; 6) use assessments to improve and evaluate learner learning” (Aliaga et al , 2010, p.1)

However, there are some challenges teachers face associated with the teaching of statistics (Garegae, 2008). There is shortage of appropriate teaching materials like

textbooks. Ben-Zvi & Garfield (2004) assert that many learners struggle with basics of mathematics, such as fractions, and this hinders their learning and related statistical concepts. They also say that teachers find it difficult to motivate learners to work hard in statistics since the statistical ideas are complex.

## **2.6 International studies participated by South Africa on mathematics teacher knowledge**

Venkat and Spaul (2015) indicate that studies on teacher knowledge evaluations of mathematics performance have been done from local to international levels. “International studies often show that South Africa has the worst educational outcomes of all middle-income countries that participate in cross-national assessments of educational achievements, especially in mathematics” (CDE Report, 2013, p.3). These include the Trends in International Mathematics and Science Study (TIMSS), National School Effectiveness Study (NSES), Programme for International Student Assessment (PISA), Southern Africa Consortium for Monitoring Education Quality (SACMEQ), and the National Senior Certificate (NSC) examinations which were looking at learner performance. A common finding on the results relates to many South African mathematics teachers lacking basic understandings of mathematics (Venkat and Spaul, 2015).

South Africa was one of the 21 middle-income countries that participated in TIMSS in 2011. TIMSS is an international standardised test for science and mathematics teachers. Although the test was meant for Grade 8 learners, Grade 9 learners in South Africa wrote the test (CDE Report, 2013, p.3). The 2011 TIMSS test revealed that South Africa had the worst mathematics results of all the countries that participated.

Venkat and Spaul (2015, p. 121) state that “An extensive body of assessment data points to poor performance in mathematics across all levels of the schooling system in South Africa”. Arends, Winnar and Mosimege (2017, p. 2) note that South African learners perform far below the international mean. South Africa held position 45 out of a total of 45 countries surveyed on Grade 8 mathematics and science assessment. The study shows the average for South Africa for mathematics to be at 264 compared to the international average of 467. The study revealed a big difference between the best and worst performing countries, where Singapore had the highest average of 605 compared to 264 for South Africa.

Teachers' mathematical knowledge is very important therefore needs to be explored, especially since many South African mathematics teachers do not have the recognised qualification to teach mathematics.

Teaching mathematics requires specialised knowledge about the subject (Hill & Ball, 2009). Mishra and Koehler (2006, p.1026) contend that "teachers must know and understand the mathematics that they teach, including knowledge of central facts, concepts, theories and procedures within a given topic, knowledge of explanatory frameworks that organise and connect ideas; and knowledge of the rules of evidence and proof". This implies that effective mathematics teachers need a thorough knowledge of the subject they teach.

There is a direct connection between learner performance in mathematics and the standard of teachers' knowledge in the mathematics content they teach (Ma, 1999). This means that teachers must have an adequate understanding of the basic ideas in mathematics in order to assist learners also to understand those ideas. Teachers need the knowledge, understandings, and connections themselves to allow a culture of learning mathematics that allows reflective thinking and reasoning in learners (Ma, 1999).

Ma (1999) studied the ways in which Chinese and US teachers teach mathematics and found out that Chinese teachers have a deeper and more coherent knowledge of elementary mathematics as compared to their American counterparts. She argued that effective teaching is based on an intense understanding of basic mathematics. This implies that effective mathematics teachers need a thorough knowledge of the subject they teach.

## **2.7 South African studies on mathematics teacher knowledge**

The CDE Report (2013, p.3) states that mathematics teaching in South Africa is amongst the worst in the world. This relates to the deteriorating achievement of learners in Mathematics over the past years, which is of great concern. There have been various initiatives and interventions put in place since 1994 to try to address this problem and improve the quality of mathematics education in South Africa, but with little or no improvement in learners' results (Pournara et al., 2015). Some of the interventions implemented by the Education Sector such as "developing and providing learners and teachers with good quality textbooks, the radical 1+4 Intervention Model

that advocates professional learning communities, and self-study Guides” are “not changing the country’s mathematics performance significantly” (DBE, 2018, p. 11).

In the South African education system, research points out that poor teacher knowledge has contributed to poor performance (CDE, 2011). National studies and assessments have been done such as the Annual National Assessment (ANA), National School Effectiveness Study (NSES), Southern Africa Consortium for Monitoring Education Quality (SACMEQ), and the National Senior Certificate (NSC) examinations which were looking at learner performance.

In the 2007 SACMEQ study, a sample of 401 Grade 6 teachers representing Grade 6 teachers at national level wrote a teacher test that consisted of 42 multiple choice questions extracted from different domains of knowledge (Venkat & Spaul, 2015). The analysis of the test showed that 79% of Grade 6 mathematics teachers revealed a content knowledge level that was below the Grade 6/7 band. Only a few teachers showed a high level of content knowledge.

Spaul (2011) also examined the results of SAQMEQ III, a study of teachers’ content knowledge, where Grade 6 learners and Grade 6 teachers wrote the same test. The sample consisted of 559 Grade 6 learners and 62 Grade 6 teachers. Bansilal (2014) asserts that it revealed that 5% of the Grade 6 learners scored more marks on the same mathematics test than the lowest 12.5% of the Grade 6 teachers in the sample. This is also indicative of the poor content knowledge of some mathematics teachers if a Grade 6 learner can score a mark higher than a teacher’s. However, there were no similar studies of Grade 10-12 teachers’ content knowledge.

A Rasch model study, which aimed to investigate content knowledge, was also done in South Africa (Bansilal et al., 2014). Two hundred and fifty-three mathematics teachers from different districts in KwaZulu-Natal, South Africa participated in the study. This sample represented about 16% of the 1 581 public high schools in KwaZulu-Natal. Only teachers who were teaching mathematics at FET band were chosen. The purpose of the study was to explore the expertise of mathematics teachers in the subject. The teachers wrote a shortened Grade 12 National Senior Certificate 2011 supplementary examination. It was reduced to seven questions due to insufficient time. Teachers who were willing to write were given two hours to write under test conditions.

The responses of the teachers were analysed and one-third of the group's cognitive levels were below level 3 and level 4 of the items in the test. According to Bansilal et al. (2014), if these results can be generalized it may indicate why there are no higher passes in mathematics. The study also showed the low knowledge levels of FET teachers who are anticipated to teach learners who will in the future write examinations similar to the one used in the study. This yet again indicates the poor content knowledge of teachers, who are teaching their learners content which they do not know themselves. This study makes it clear that it is vital for teachers to have a thorough understanding of the basic concepts in their subjects with regard to content knowledge.

South African studies that focus on teacher knowledge and learner performance have provided evidence of the relationship between teacher knowledge and learner performance (Carnoy & Arends, 2012). Two case studies were conducted in South Africa in Gauteng (Carnoy & Chisholm, 2008) and Northwest provinces (Carnoy & Arends, 2012). The studies focused on the effect of teacher knowledge and learner performance, both studies trying to measure content knowledge and pedagogical content knowledge of the teachers. Grade 6 learners and teachers in 40 schools in the Gauteng province participated.

Carnoy & Chisholm (2008) indicate that the findings showed that the teachers employed in schools with mostly African and mixed-race learners had lower scores in both content knowledge and PCK, as compared to the teachers employed in schools formerly reserved for white learners and Independent schools. Teachers from the North West province were found to have less content knowledge and PCK. Teachers with higher content knowledge, especially pedagogical content knowledge, are more likely to be teaching in wealthier schools that are independent (Shepherd, 2013). This somehow shows a link between learner's race and 'wealthy schools'.

According to Taylor, Van der Berg & Mabogoane (2013), a National Science Education Standards (NSES) research study was done, where Grades 4 and 5 teachers from all South African provinces except one, wrote a short test based on Grade 6-related curriculum questions. The questions focused on the addition of fractions, rounding off, time, perimeter and composite shapes. The results and analysis of the test revealed gaps in the teachers' knowledge. The analysis showed that 64% of Grade 4 teachers and 68% of Grade 5 teachers got the question on rounding off and estimation correct.

That was the highest performance indicated. Fifty percent of the teachers from both grades got the questions on the addition of fractions, time, and pattern continuation correct, and lastly only a third of teachers in both grades got the perimeter question correct. This implies that if the teachers lack important basic content knowledge this can have an impact on learner achievement.

In another study of NSES in 2007, 2008 and 2009, Carnoy et al. (2011, p. 89) also found that Grade 6 teachers from North West province got an average score of 40% on an extended test consisting mainly of Grade 6 items. This was evidence of the poor standard of teachers' content knowledge as they were not able to answer questions in the curriculum they were teaching (CDE Report, 2013).

A study reported by Hugo et al. (2010) from KwaZulu-Natal revealed that not a single Grade 6 teacher was able to achieve 100% for the test of the curriculum they were teaching, 24% achieved less than 50% on the test and, in each test question, an average of 47% got correct answers. This shows the poor content knowledge of teachers.

Kazima, Pillay and Adler (2008) also did studies to explore the mathematics for teaching. Two teachers participated in the study in the teaching of mathematics in two different public schools in Gauteng. The two studies formed a part of the QUANTUM research project, which specifically focused on Mathematics for Teaching (MfT). The case studies investigated the "mathematical knowledge teachers need to know, and know how to use, in order to teach mathematics well" (Kazima et al., 2008, p.284). The case studies focused on the teaching of Grade 8 probability and Grade 10 functions, in terms of problem solving and mathematical work.

Teachers need to know how to do mathematics and how to use mathematics in practice (Adler, 2004). This means that to teach mathematics, the teacher needs to know not only about the topic to be taught, but also "needs to know more than doing mathematics for him or herself" (Kazima et al., 2008, p.283).

## **2.7 Pedagogical decision-making**

Pedagogical decision-making is the process teachers engage in in their classroom that justifies the choice among available alternatives, based on considerations that are expected to bring about fruitful and relevant learning by learners (Rajendran et al.,

2006). Teachers' pedagogical decision-making is a growing process and is linked to the actual pedagogic practice. The teachers' mathematical knowledge must be deep and strong in order for them to make wise decisions in the teaching of mathematics (Ma, 1999). Teachers make many decisions during the period of teaching a lesson. This is very important in mathematics teaching as this process is a pedagogical one. Teachers must have the capacity to link all this information to their knowledge of the teaching-learning process in order to guide their teaching actions. Teachers' pedagogical decision-making is also influenced by the learners' current knowledge; they build on existing proficiencies, adjusting their teaching to meet learners' learning needs.

### **2.7.1 Importance of decision-making**

The ability to make decisions and construct possible solutions in a teaching situation is important. Learning depends on the pedagogical approaches and choices of teachers in the classroom. Of all curriculum subjects, mathematics is the one studied in most countries and, as in other subjects, the teachers' understanding of their subject influences their decision-making in the teaching situation. The best teachers believe in the ability of their learners to learn, and carefully use a variety of pedagogical approaches to ensure this learning occurs. What teachers think, believe and do in the classroom determines the kind of teaching that learners get (Hargreaves, 1994). Rowland (2005) observed that PCK contributes to the decisions and actions of teachers. Pedagogical choice success depends on understanding the particular subject matter they are teaching, and understanding the needs of different learners and the surrounding contexts.

Various researchers point out that there is a link between teacher's pedagogical content knowledge and the examples used by the teacher in teaching, implying that a teacher's PCK is vital for their choice of appropriate examples in the classroom. For example, the decision of a mathematics teacher to choose a particular example is guided by his PCK (Chick, 2007).

This connects with the domain of knowledge of content and students (KCS) because the examples chosen by the teacher must foster leverage of coherent example sets by the teacher to build students' understanding. Pedagogical decision-making is important because teachers need to choose those examples that allow them to

attend to common errors and misconceptions and to forewarn their learners of these (Zodik & Zaslavsky, 2008). This view concurs with that of Ball et al. (2008), who assert that knowledge of learners' conceptions and misconceptions implies that the teacher must choose examples that are transparent so that learners are not confused. Pedagogical decision-making is also important so that teachers can change their instruction strategies and activities to meet the need of each learner.

## **2.8 Conclusion**

This chapter described the concept of teacher knowledge with reference to various literatures from various authors. It described PCK in terms of Shulman's (1986, 1987) domains of teacher knowledge and Grossman's (1990) domains of teacher knowledge. I highlighted seven domains of teacher knowledge according to Shulman and Grossman's four aspects of teacher knowledge domains. The framework of the study was described using Ball et al.'s (2008) theory of MKT. The chapter reviewed choices in pedagogical decision-making and the importance of pedagogical decisions. Lastly, it described the relationship between PCK and pedagogical decision-making. The next chapter will look at the research methodology used in this study.

# CHAPTER 3: RESEARCH METHODOLOGY

## 3.1. Introduction

This study sought to explore the pedagogical content knowledge of mathematics teachers in the Harry Gwala District, in KwaZulu-Natal. The study followed a case study design and used a qualitative methodological approach within the interpretivist paradigm. This chapter discusses the interpretive research paradigm as well as the qualitative methodological approach. It defines and justifies the case study research design according to the interpretive paradigm, and highlights the strengths and weaknesses of case study. The data collection methods are explained, and lastly the ethical issues and trustworthiness of the case study research design are discussed.

## 3.2. Research Paradigm

Willis (2007) states that a paradigm is a concept that leads and informs a research study. Mackenzie & Knipe (2006) define a paradigm as a “worldview” of the researcher. The approach to this study is justified by the interpretivist paradigm. Perren and Ram (2004), in line with (Willis 2007), assert that it is important and worthwhile to position research within a paradigm as this will help researchers to “reflect upon the broader epistemological and philosophical consequences of their perspective” (p. 95).

Brynard, Hanekom & Brynard (2014, p. 37) contend that the “interpretive research paradigm is characterized by a need to understand the world as it is from a subjective point of view.” It relies upon participants’ views of the situations being studied, rather than the researcher’s perspectives. Similarly, Cohen et al. (2018) add that interpretivists try to perceive how an individual interprets the world around them. They see the reality of life in a social group through the lens of the participants rather than as an outsider. Similarly, Bertram & Christiansen (2014) point out that the interpretivist approach tries to understand the social world in the context in which it exists naturally. This paradigm recognizes that subjectivity is important; however, it does not completely rule out objectivity.

The ontology and the epistemology of interpretivist theories inspired my choice of the research paradigm. This approach has the advantage that the researcher and the participant will have close collaboration. Reality can only be understood if interpretation is done subjectively, as subjectivity is the key to how we reach our understanding of what constitutes reality. Interpretivists use different research designs to construct reality. These include, among others, action research, case studies and ethnography.

Epistemologically, interpretivists contend that social reality is subjective as it depends on human experiences and on how people feel about the world. Thus, interpretivists accept multiple meanings, recognising that different people see things in different ways. Corbin and Strauss (2008) assert that meaning or reality depends on the subject. The meaning of reality is interpreted by an individual through sense-making. I chose this paradigm because it contends that knowledge is created through interactions. Since I want to explore and understand the pedagogic actions of teachers, interacting with the study participants enables me to make sense of why they teach the way they do.

### **3.3. Methodological approach**

Brynard et al. (2014) state that research methodology is how data is collected and processed, based on the framework of the research process. This study used a qualitative research approach based on the interpretivist paradigm. Brynard et al. (2014, p.37) assert that “Qualitative methodology refers to the research that produces descriptive data – generally the participant’s own written or spoken words pertaining to their experience or perception”. Qualitative methodology connects with the interpretive paradigm as it views the world from the perception of the participant. De Vos et al. (as cited in Brynard et al., 2014) contend that in qualitative research the researcher is concerned about interpreting something in a certain way rather than explaining it.

Qualitative research mainly uses relatively small samples, chosen intentionally to allow an investigation into and an understanding of a phenomenon in depth (Cohen et al., 2007). I chose qualitative methodology because it generates in-depth data. As I conducted interviews with the participants, they explained their pedagogic actions according to the way they viewed things themselves. Creswell (2009) also adds that

qualitative methodology engages conversation with participants in a natural setting. The participants in this study were three teachers teaching grade 10 mathematics from three different schools.

### **3.4. Research design**

This study used a case study research design. Such a design seeks to explore a system over a period of time through a comprehensive and thorough data collection involving various sources of information and rich in context (Merriam, 1998). Rule and John (2011, p.4) define a case study as a systematic and in-depth study of a single particular case in its context. The case may be a person, a group of people or an organisation. My case involved three Grade 10 teachers from three different schools.

The aim of the case study research design is to illustrate, examine and interpret the differences between real individuals and situations through participants' explanations and available reports. Cohen et al. (2018) argue that case studies represent reality and a sense of being there.

The study purpose determines the selection of a specific type of case study. This study used an exploratory case study design, which is a form of qualitative research. I chose exploratory case study design because I wanted to explore the PCK of three mathematics teachers. I chose it because it could give an in-depth insight into how the three Grade 10 mathematics teachers used their PCK when teaching mathematics.

#### **3.4.1. Limitations to research design**

The most critical limitation I experienced in this research was time. I collected the data in the third term, which is short and teachers are busy trying to finish syllabi in preparation for end-of-year examinations. However, I collected the data in the first weeks of the opening of schools, before schools were too busy. Collecting data under time constraints might have affected how much data the participants gave me.

As I thought that the teachers' responses to the interview questions might not fully reveal the extent of their understanding of PCK, I explained the meaning of PCK to them before conducting observations and interviews. In addition, I thought my position as a cluster coordinator in the circuit might influence the responses of the participants, making them not to be entirely honest. A cluster coordinator is a selected teacher within a group of schools in a ward who assists the subject advisor in leadership roles,

for example, moderating examination papers, supporting new mathematics teachers professionally, coordinating activities in mathematics workshops and so on. Therefore, I made the respondents aware that in the study, my position as cluster coordinator had nothing to do with the study.

### **3.4.2. Strengths of case study**

In a case study the researcher has the ability to use various research methods, establish rapport with the participants and acquire rich information. A case study provides in-depth insight. Its results are easy to understand since researchers use everyday language and this enables the results to be understood by a wide range of people (Cohen et al., 2018). Case studies are “strong in reality” (Cohen et al., 2018, p.379), they are practical and reasonable and they engage both the researcher and participant. A case study can be conducted by one researcher.

### **3.4.3. Weaknesses of case study**

The outcomes of a case study may not be generalized. This means that a case study can be considered weak. Its findings cannot be generalised since it’s not easy to find similar cases. Furthermore, different researchers interpret the same data differently, implying that the researcher’s own feelings may have an influence on the case study. Case studies are time-consuming to conduct. There can be a problem of observer bias and they are also not easily open to cross-checking (Cohen et al., 2018). They are difficult to replicate.

## **3.5. Research context**

The study took place in the Harry Gwala district in KwaZulu-Natal. There are 81 secondary schools in this district. The enrolments of the schools in the district vary between 300-1000 learners. The majority of the schools in the district are non-fee-paying schools. I selected three schools in semi-rural areas where there are quintile 1 to 4 schools. The schools were not selected to represent the different quintile status but were selected based on convenience to the researcher. Rural areas are characterised by poverty, and the children from rural schools come from low-income backgrounds. There is low population density and society has homogeneity in terms of culture and language. Schools in rural areas are poorly resourced in terms of water, buildings, educational facilities and so on. One school is quintile 3, the second one is quintile 2 and the third one is quintile 4. Schools in quintiles 2 and 3 do not pay school

fees and receive more government funding than the quintile 4 school, where fees are paid. “Poor schools that are ranked in quintiles 1, 2 and 3 are no-fee schools, and are allocated a higher state subsidy than the affluent schools in quintiles 4 and 5” (Arends et al., 2017, p. 3). The two schools where parents do not pay fees have poor to limited resources like textbooks and furniture, while the fee-paying school is well equipped with textbooks, furniture, computers, teachers and buildings. The learner numbers in the three schools range from 700–1000 and each school has one Grade 10 class with an average of 40 learners doing mathematics.

### **3.6. Research sampling**

Maree (2007) defines sampling as a selection of the population for study from a certain group of people. Bertram & Christiansen (2014) assert that it involves decision making regarding the people, settings and behaviours to put in the study. In this study, purposive and convenience sampling was employed with a specific purpose of exploring the pedagogical content knowledge of Grade 10 teachers in mathematics.

According to Bertram & Christiansen (2014), convenience sampling entails the researcher choosing a sample that is easily accessible to him/her. I used convenience sampling to select schools that were in the same circuit and close to my school, so that it was inexpensive and easy to access the schools. The schools were also selected to represent a range of schools with different resources, as can be seen from the fact that one of the schools is in quintile 4, although still in a rural geographic location.

I purposely selected the Grade 10 mathematics teacher in each of the selected schools. Purposive sampling makes “specific choices about which people, groups or objects to include in the sample” (Bertram & Christiansen, 2014, p. 60). I chose purposive sampling as appropriate to the particular purpose of my study, which was to investigate the PCK of mathematics teachers. I needed teachers that were all teaching Grade 10 mathematics and would be willing to participate in the study. All three of the teachers also had at least three years’ teaching experience in Grade 10 mathematics.

### **3.7. Data collection methods**

The study used the qualitative research methods of interviews and direct observation to collect data. I used observations and video-recordings of lessons in order to generate data in the classroom on how the teachers taught, the strategies they used, and how they helped the learners to understand some concepts that they (the learners) misinterpreted.

#### **3.7.1 Classroom observation**

Cohen et al. (2018) state that an observation is observing people in an orderly manner, noting their behaviours, events, settings and so on, and this study employed structured observation. I knew clearly what I was looking for in the classroom, that is why I used structured observation. In this method, the researcher is present at the place of study, in this case, in a classroom, and looks at what exactly is taking place (Bertram & Christiansen, 2014).

I chose classroom observation because I wanted to be able to observe and take note of the teachers' practice so that it could be discussed during an interview. I also wanted to witness exactly what happened in class as the teachers taught, and have my own facts of the number of learners in class, the amount of interaction between the teachers and learners, how the teachers responded to learner questions, especially misconceptions, and how the teachers displayed their PCK during teaching. Observation allowed me to answer the research question on how the teachers showed their PCK in teaching mathematics.

Observation has its strengths and weaknesses. The strength is that it is a very powerful tool for gaining insight into events (Cohen et al., 2018). Bertram & Christiansen (2014) assert that it also helps to collect information on many things like the state of the school, teacher classroom practices, the interactions taking place in the classroom and so on. However, with observation it may take time to observe and understand the phenomenon of the study.

The lessons were also video recorded. Cohen et al. (2018) contend that "video recording can overcome the partialness of the observer's view of a single event..." The reason I chose video recording, was so that I would have a full view of the activities that were happening in class.

Observation schedules (see Appendix 7) were used as the data collecting instruments. I did the observations after normal school hours in the Grade 10 classrooms and the lessons were specially meant for the study. Ethical clearance for the study was received late, which affected my data collection plan and created many time constraints. I had to observe lessons in term 3, a very short term during which I also lost many teaching hours when attending a number of workshops for Grade 12 teachers. The participating teachers and I were also very busy with matric learners and preparing for trial examinations. I therefore observed the lessons after school to avoid disturbing the normal school timetable. Observing the lessons after normal school hours did not have much influence on my study, although some of the learners could not attend the lesson because of transport constraints. I did the video-recordings myself.

### **3.7.2 Interviews**

Cohen et al. (2018) define an interview as the sharing of information between people with the same understanding of the issue at hand. Similarly, Bertram & Christiansen (2014) define it as talk between the researcher and the participant. I chose interviews as a data collection procedure because they would reveal more detailed meanings regarding the PCK that teachers brought to class. As the study sought to explore the PCK of Grade 10 mathematics teachers and the relationship between their PCK and pedagogic actions, I saw interviewing as “an obviously useful method, since it allows the researcher to ask probing and clarifying questions, and to discuss research participants’ understanding of them” (Bertram & Christiansen, 2014, p.82). Semi-structured interviews also helped me to establish rapport with the participants and get first-hand information from them. The semi-structured interviews helped me to find out information on the research questions that shows how the teachers acquired the knowledge that they have and if the teacher content workshops improve their PCK (see Appendix 8 for the interview schedule).

Interviews have advantages and disadvantages of which only a few will be highlighted. Some advantages of interviews include: 1) interviewing can give the researcher more detailed and explained data than using a questionnaire; 2) the researcher is present and can clarify questions to the participant; 3) the researcher can probe when insufficient information is given by the participant; and 4) it is less effort for participants

to talk to the interviewer than to write long answers in a questionnaire (Bertram & Christiansen, 2014).

The disadvantages are 1) power relations can impact the process, for example, since I am a cluster coordinator this might have an effect on the responses I got; 2) large amounts of data can be obtained which need to be transcribed, maybe taking many pages; 3) the participants give responses based on themselves and their beliefs which might not be the case when the researcher observes them.

I did the pre-lesson observation interviews first, then observed the lessons. The post-lesson observation interviews were done after I had viewed the videos. I arranged them on Saturdays in the schools where the teachers teach, since they were attending Saturday classes in their schools. I did audiotaping during the interviews so that I would get the exact words of the respondents and transcribe them after the interviews were conducted. It was not possible to transcribe during the interview sessions since I might have missed out some information when writing.

### **3.7.3 Video-stimulated recall interviews**

The study also collected data through video-stimulated recall interviews. I video recorded each teacher's lesson as a basis for the video-stimulated recall interview. Video-stimulated recall interviewing is a data-generating method whereby the participants view their behaviour and reflect on why they behaved the way they did and their decision making process during the videoed occasion (Nguyen, McFadden, Tangen and Beutel, 2013). Lyle (2003) contends that the aim of stimulated-recall interviews is to gain deeper knowledge of why participants choose to teach in certain ways.

The stimulated-recall interviews (SRIs) were done three days after the lessons were observed. Gass and Mackey (2010) encourage researchers not to delay between when the video was recorded and the recall interview in order to increase validity. I decided to use SRIs so that each teacher had the opportunity to view the video with me so that they could see how they taught and reflect on their teaching behaviours and pedagogic decisions. The video-stimulated recall interview was used to trigger discussion to recall what happened when the teacher was teaching and his actions. The video supported reflection on the teacher's mathematical practice. The SRIs helped me to understand and gain insight into why the teachers started their lessons

by recapping on previous knowledge, their sequencing of lessons and how they addressed learner misconceptions.

However, SRIs can also have limitations; for example, one of the teachers was excited when watching the video and forgot the purpose of recalling and reflecting on the teaching event.

Muir & Beswick (2007) state that a video recording provides a means of purposeful reflection. Cohen et al. (2018) contend that “video recording can overcome the partialness of the observer’s view of a single event...” I chose video recording so that I would have a full view of the activities that were happening in class. I watched the videos in my own time after the lessons and asked the teachers to watch the videos so that they could see how they taught. One disadvantage of using video recording is that the behaviour of the participants might change as they are being observed.

### **3.8. Data analysis**

The study employed qualitative data analysis. Cohen et al. (2018, p. 643) assert that this includes “organizing, describing, understanding, accounting for, and explaining data, making sense of data in terms of participants’ definitions of the situation, noting patterns, themes, categories and regularities...” It is a continuous process where data is managed, making sense of the evidence through detailed accounts. The exact words of the respondents were transcribed, organised and coded as well as the classroom observations and teacher actions.

There are two ways of dealing with data analysis: inductive reasoning and deductive reasoning. Where common themes and patterns were identified, inductive analysis was done, especially from the semi-structured interviews that were done before the lesson and after the observation. Deductive analysis was used for the lesson observation, using Ball et al.’s (2008) framework so as to explore the concepts of KCS, KCT and KCC within the PCK category of teacher knowledge displayed by the teachers during teaching. These have been explained in Section 2.4. Data relevant to the research was coded and data not relevant to the research was put aside.

### **3.9. Trustworthiness**

Minimising the amount of bias also helps in achieving better trustworthiness (Cohen et al., 2011). Respondents must be true and honest in their responses so that the data

is valid during interviews. The researcher also guaranteed credibility by ensuring that findings are confirmed by someone else like the supervisor, or member-checking. I did member-checking to ensure that exact responses were transcribed. The transcribed data was given to the participants to check if everything they said was included and correctly transcribed. Lastly, I disseminated the benefits of the research to the participants and other teachers by conducting a workshop giving feedback of the findings and discussing way forward.

### **3.9.1 Role of researcher**

My position as a cluster coordinator in the circuit may have influenced the study, as teachers might not have been honest enough in their responses in interviews. A cluster coordinator coordinates the mathematics teachers in a ward. A cluster coordinator assists the subject advisors in duties like the moderation of examination scripts and formal tasks for learners for quarterly common examinations, organising cluster meetings for setting common tasks, mentoring new mathematics teachers and assisting in teacher development workshops. This position might have scared the teachers as, they might have thought I wanted to observe them teaching because I was on a fault-finding mission as their leader, so they might not have given me all the information I needed. They were made aware that I was a researcher and my position as a cluster coordinator in the circuit had nothing to do with the study.

### **3.10. Ethical considerations**

Cohen et al. (2018) state that ethics are concerned with what is good and what is bad. Researchers should know what they should and should not do in their research. I requested ethical clearance from the Department of Basic Education and the University of KwaZulu-Natal ethical clearance committee for authorization to do research in the participating schools. I got ethical clearance from both institutions to carry out the research (please see Appendix 2).

I contacted the principals and teachers of the schools involved to ask for permission to do the study in their schools. I made appointments with them and met with them in their schools to explain the purpose of the research. I wrote a letter to get informed consent from the principals of the schools concerned, the teachers, the learners who would be in class during the observation lesson and their parents. The participants signed the informed consent forms as they were fully aware of the intentions of the

study. I ensured my trustworthiness by respecting the autonomy of the participants, not forcing them to participate and assuring them that they could withdraw at any time if they were no longer willing to participate. I assured the participants that no harm would be done to them and that their privacy, confidentiality and anonymity were assured. Pseudonyms were given to the participants and the schools involved.

### **3.11. Conclusion**

This chapter presented information on the research design and methodology that was used to do this research. It highlighted justification of the research design and methodology. The research was placed in the interpretivist paradigm, using case study design. The term case study, as defined by various authors, was explained and the strengths and weaknesses of case study highlighted. The data collection methods used in the study were discussed. I used purposive and convenience sampling to select three Grade 10 teachers. My methods of data analysis were also explained. Ethical considerations and trustworthiness were discussed, and the limitations of the study were highlighted. The next chapter presents and discusses the data collected.

# **CHAPTER 4: Presentation of the findings**

## **4.1 Introduction**

This chapter presents the analysis of the data collected from lesson observations, pre- and post-lesson teacher interviews and video-recall stimulated interviews. It explores the teachers' characteristics of PCK based on Ball et al.'s (2008) framework. The chapter also provides the biographical details of the three Grade 10 mathematics teachers.

## **4.2 Analysis of data**

Cohen et al. (2011) define data analysis as a continuous and repetitive process where data is managed, making sense of the evidence through descriptive accounts.

Data analysis brings order, structure and meaning to the collected data (Saunders, Lewis & Thornhill, 2009). Deductions and inferences are made after the collected data is examined. The chapter presents the lesson observation description for each teacher and analyses it with respect to the three components of PCK according to Ball et al. (2008). These are knowledge of content and students (KCS), knowledge of content and teaching (KCT) and knowledge of content and curriculum (KCC). The interviews were coded according to the same components of PCK, which have been described in Chapter 2.

In the study, pseudonyms are used for the three teachers as well as the schools. The teachers were given pseudonyms teacher 1 (T1), teacher 2 (T2) and teacher 3 (T3) and the schools school 1 (S1), school 2 (S2) and school 3 (S3) respectively.

## **4.3 Teacher biographies**

In the pre-lesson teacher interviews, I asked the teachers to describe their qualifications, teaching experience, the grades they were teaching, the purpose of the lesson, how they decided on the teaching strategies and resources used and the misconceptions they were anticipating from the learners. The table below shows the biographical details of the three teachers who participated in the study.

**Table 2: Biographical details of participants**

Participant	Gender	Race	Years of experience	Qualification	Grades taught	Name of school
Teacher 1 (T1)	F	African	17	Senior teaching diploma, B.Ed. in Mathematics and Natural Science, ACE Mathematics Certification	10,11	S1
Teacher 2 (T2)	M	African	3	B.Ed. (Mathematics and Geography)	9, 10, 11	S2
Teacher 3 (T3)	M	African	5	Honours in Applied Mathematics. No teaching qualification	9,10,11,12	S3

#### **4.3.1 Teacher 1 (T1) at School 1 (S1)**

The teacher from the first school was qualified to teach mathematics. She holds a Senior Teaching Diploma, B. Ed in Mathematics and Natural Sciences and Advanced Certificate of Education Mathematics (ACE). However, T1 did not do any statistics module in her studies. She taught herself statistics by going out and finding resources for herself. Batanero, Burill and Reading (2011) assert that there are few teachers at present who are trained in how to teach statistics. The qualifications of teachers may contribute to inadequate PCK. The teacher was asked if she knows about PCK and she indicated that according to her opinion it refers to knowing of subject content and how to teach it.

T1 is in her 17<sup>th</sup> year of teaching. She indicated that she was teaching mathematics from 1993 to 2008 at a Junior Secondary School. She now teaches mathematics in the FET phase at Grades 10 and 11. The teacher highlighted that she started teaching Grade 10 in 2011 and she taught only that grade during that year. Then the Grade 12 teacher left the school, and T1 had to teach Grade 12 since she was the only teacher left. She started having problems with Grade 12 because the learners lacked foundational knowledge in mathematics. In 2019 she decided to go back to teaching Grade 10 so that she could start teaching mathematics foundational knowledge from Grade 10.

The school is located in a peri-urban area but still regarded as a rural school. It is poorly resourced in terms of buildings and furniture. The buildings are old and the 14 classrooms are small, with not enough desks for learners and teachers. There are 749 learners in the FET phase, with 25 teachers for the entire school. There are 81 Grade 10 learners and three mathematics teachers in the school. According to the teacher, girls outnumber boys. The school's average pass rate in Grade 12 is 42%.

#### **4.3.2 Teacher 2 (T2) at School 2 (S2)**

The teacher from the second school was qualified to teach mathematics. He holds a Bachelor of Education degree, and majored in mathematics and geography. T2 has three years' teaching experience in mathematics. He teaches Grade 10 mathematics and Grade 11 mathematical literacy. T2 had an idea of what PCK is. He understood PCK as thorough knowledge of content and how to teach it.

The school is located in a peri-urban area but still regarded as a rural school. There are about 600 learners and 27 teachers in the school. There are 64 learners taking Grade 10 FET mathematics and five mathematics teachers for the entire school. The school is well- resourced in terms of buildings and furniture, with 20 classrooms and enough desks for learners. There are two Grade 10 classrooms. The average pass rate in mathematics in Grade 12 is 60%.

#### **4.3.3. Teacher 3 (T3) at School 3 (S3)**

The teacher from the third school holds a qualification in Honours in Applied Mathematics. He studied statistics as one of the majors. He said the degree he studied had nothing to do with teaching, but was equipped with enough content to teach high school learners. He does not have a teaching qualification. Thus, he did not learn anything about PCK in university. However, he said he thought pedagogical knowledge is about how concepts are delivered to children and content knowledge is how much you know about the subject. T2 started teaching Mathematics in 2016 and Grade 10 was his first grade to teach in FET. He also teaches Grades 8 and 9, and 11 and 12.

The school is located in a peri-urban area but still regarded as a rural school. It is a quintile 4 fee-paying school. There are 54 learners taking Grade 10 mathematics and there are four mathematics teachers in the school. There are enough desks and chairs

for the learners. The buildings are still in good condition. The average Grade 12 pass rate is 65%.

#### 4.4 Box and whisker plots as a curriculum topic in Grade 10

##### Prior knowledge from Grade 9

By Grade 10, learners are expected to know the definitions of terms used in statistics and can distinguish between median and measures of central tendency. These concepts are introduced in Grade 7 of the curriculum, and employed in Grades 8 and 9.

##### 4.4.1 Grade 10 statistics according to the CAPS curriculum

**Time allocation: 2 weeks Term 3**

**Paper 2 (15 marks)**

**Table 3: Grade 10 statistics according to CAPS curriculum**

Grade 10	Link to Grade 11
Collect, organise and interpret univariate data in order to determine: <ul style="list-style-type: none"> <li>•Measures of central tendency</li> <li>•Five number summary</li> <li>•Box and whisker diagrams; and</li> <li>•Measures of dispersion</li> </ul>	Represent skewed data in box and whisker diagrams, and in frequency polygons. Identify outliers.

The box and whisker plot is one of the most confusing and misunderstood diagrams for both teachers and learners in South Africa. Box and whisker plots are graphical statistical methods of analysing data (Kortenkamp and Rolka, 2010). They provide the visual representation in which the data set is centralized and spread using the five number summary. The five number summary comprises the main values used in drawing the box and whisker plot. The five number summary consists of the minimum value, lower quartile, median, upper quartile and maximum values. The minimum value is the lowest value in the data set and the maximum value is the highest value in the data set. The median ( $Q_2$ ) is the middle value when first the data set has been arranged in ascending order and it divides the data set into two parts, namely, the lower half and the upper half. The lower quartile ( $Q_1$ ) is the median of the lower half of

the data set and the upper quartile ( $Q_3$ ) is the median of the upper half of the data set. Thus, the box and whisker plot does not show any frequencies and this can be a source of misconception. Its information is contained in a single display all at once (Bakker, Biehler & Konold, 2004)

Chick and Pierce (2013) assert that the following concepts are vital for learners to be able to interpret the box and whisker plots: quartiles, median, minimum, maximum, range and inter-quartile range. Learners face a number of challenges with regard to interpreting box plots (Lem, Onghema, Verschaffel & Doreen, 2014). The DBE Reports (2011, 2012, 2013) indicate that South African learners have challenges concerning the box and whisker plots, being unable to link the five number summary and the plotting of the box and whisker.

The box and whisker plot is divided into four parts, each contributing 25% of the data entries. This differs from most statistical diagrams, where one can easily read data frequencies (Bakker et al., 2004). Many learners therefore think that the larger box represents a higher concentration of data, that is, there are many data items in that box. They fail to interpret the parts of the box plot as measures of centre or spread. Instead, they regard the median as a middle term rather than a summary where the data is centred.

#### **4.5 Lesson Observation of teacher 1 [school 1]**

There were 45 learners in total in the lesson, although the class register has 81 learners for this class. There were more girls than boys in the classroom. The classroom was small and the learners were packed, sitting very close to each other. There wasn't enough space in front for the teacher to walk freely. The lesson took one hour. The school is poorly resourced in terms of infrastructure. The classrooms are insufficient and the buildings are old and with cracks.

##### **4.5.1 Teacher 1: Description of lesson**

###### **Topic: Box and Whisker Plot**

The lesson started at 15:00 after school. It was arranged as an extra lesson to accommodate my research, since I was not able to leave my school during teaching hours because of a tight timetable. As I teach Grade 12, a lot of my teaching time was lost when I had to attend workshops, so I did not want to further disturb teaching time

and thus disadvantage many learners. The concepts to be taught were sketching of the box and whisker plot and interpreting it. T1 started the lesson by recapping the five number summary (explained in section 4.4.1). She highlighted that the concepts on which she was focusing were the five number summary and the box and whiskers, and she was also going to look at quartiles. The teacher also indicated that she was going to recap on fractions from grade 9 to make it easier for learners to understand quartiles. Before the lesson, T2 showed me a concept map of her lesson plan on the box and whisker plot.

**Table 4: Lesson observation Teacher 1**

<b>Lesson observation description</b>	<b>Analysis of lesson using PCK characteristics</b>
<p><b>Introduction</b> 15:00-15:20</p> <p>T1 started the lesson by recapping a previous lesson on the box and whisker plot. She asked learners what the five number summary consists of and pinpointed individual learners to come to the board and write down any item they knew in the five number summary. The learners came to the board and each wrote one item from the terms minimum value, lower quartile, median, upper quartile and maximum value</p>	<p><b>Knowledge of content and curriculum</b></p> <p>T1 displayed a characteristic of KCC as she started the lesson by finding out what the children already knew about the measures of central tendency. She asked simple questions, like: what is the maximum value, minimum, median and mean in a given data set? She also asked the learners to arrange the data in ascending and descending order.</p>
<p><b>Lesson development</b> 15:20-15:50</p> <p>T1 explained how to draw the box and whisker using the five number summary. She put an example on the chalkboard and asked individual learners to come to the board to write the values of the five number summary. She just called any learner, they were not given the chance to raise their hands.</p> <p><b>Step 1: Five number summary</b></p> <p>T1 asked the learners to copy the example on the chalkboard and picked individuals to come to the board and write the values of the five number summary. She emphasized that the learners must first arrange the entries in the data set in ascending order before writing down the five number summary. T1 asked the learners the values of the five number summary of the example taking them from the data set. The learners did not have</p>	<p>T1 demonstrated knowledge of content and curriculum as she unpacked the concept of the box and whisker.</p> <p>KCT was evident from how the T1 explained and delivered the lesson. She made sure that she had the attention of the learners before delivering the instruction. She used questioning as part of her instruction in order to check their understanding.</p> <p><b>Knowledge of content and teaching</b></p> <p>T1 showed characteristics of KCT by the way she sequenced her concepts in order for the learners to understand the basic concepts before taking them to the deeper content of interpreting and problem solving. She started by explaining what the box and whisker and five number summary are, sketching these and then commenting on them. This was easy for the learners to follow. T1 even used an instructional strategy of lecturing first so that she could explain all the concepts prior to engaging the learners in activities. T1 also displayed KCT as she used the chalkboard so</p>

problems with minimum and maximum values.

### Step 2: Finding quartiles

T1 explained that the learners first needed to find the median before finding the lower and upper quartiles. She then explained how to find the quartiles using formulae.

$$Q_1 = \frac{n + 1}{4}$$
$$Q_2 = \frac{n + 1}{2}$$
$$Q_3 = \frac{3(n + 1)}{4}$$

She explained that as they use the formula what they get is not the values of the quartiles but the positions of the quartiles. If they get the position of the quartile they must simply go to the data set and find the value at that position. The learners first had the misconception that the position is the actual value of the quartile.

### Step 3: Drawing the box and whisker

When the five number summary (see 4.4) was written on the chalkboard T1 demonstrated how to draw the box and whisker diagram on the chalkboard. She told the learners that they must draw a number line with a suitable scale first. The teacher explained that the box encloses the quartiles. T1 also explained that the median can be closer to the lower quartile or the upper quartile or anywhere between the lower and upper quartile. She explained that the whiskers start from the minimum value to where the lower quartile starts and from the upper quartile the maximum value. T1 explained that the learners must label the five number summary.

### Step 4: Commenting on the box and whisker

T1 then explained that the learners must be able to comment on the distribution of data on the box and whisker diagram. She said they must state whether the box and whisker was symmetrically distributed, skewed to the left or skewed to the right. She explained that they should look at the distance from the median to the maximum value or from the median to the minimum value. The distance determines the

that all learners could see as she was demonstrating the sketching of the box and whisker.

### Knowledge of content and students

When the teacher was explaining the quartiles she reminded the learners again and again that the formula for quartiles was used to find the position of the quartile, not the quartile itself. This shows that the teacher displayed KCS because she anticipated that some learners were going to write the position as the quartiles. She already knew the misconceptions of the learners in this concept that's why she reinforced the concept. T1 also displayed KCS by first revising fractions with the learners so that they could understand the quartile. She did this by asking the learners about a quarter, half and three quarters, then linking that to quartiles, showing that the data set would be divided into four parts.

### Knowledge of content and curriculum

T1 displayed KCC as she referred to a policy document for the concepts she had to teach. She also used a textbook and past examination papers which are CAPS compliant. T1 also displayed knowledge of content and curriculum when she linked Grade 9 work on fractions with quartiles.

### Knowledge of content and teaching

T1 showed a characteristic of KCT when she used another method to comment on the box and whisker diagram. She used the strategy of comparing the mean and median.

<p>skewness of the box and whisker diagram. If the distance is equal then it is symmetrical.</p> <p>On the other hand, T1 said, the learners could compare the mean and median to do the commenting.</p> <p>She asked them the distribution if:</p> <p>(a) mean=median (b) mean&gt;median (c) mean&lt;median</p> <p>T1 did another example but asked learners to come to the board to do it.</p> <p><b>Step 4:Class activity</b></p> <p>T1 gave learners some classwork to do and she monitored individuals, assisting those who had problems.</p> <p>She marked learner's books as she was supervising the classwork.</p>	<p>T1 demonstrated an understanding of knowledge of content and students by the examples and tasks she selected. The examples were easy to understand, thereby motivating the learners, and she chose examples which demonstrate real life situations.</p>
<p><b>Conclusion</b></p> <p>The teacher concluded the lesson using the question and answer method and consolidating the concepts learnt. She then gave the learners homework.</p>	<p>The teacher displayed KCS as she chose tasks that learners were not going to find too difficult for homework. She chose tasks that would enable them to see if they understood what was taught in class, rather than giving them homework of concepts that she did not teach.</p>

#### 4.5.2 Teacher 1: Lesson observation analysis

##### Knowledge of content and curriculum (KCC)

Teacher 1 displayed KCC as she used textbooks and chalkboard during the lesson. The textbooks were used for homework exercises to be done at home. The chalkboard was used to write notes and demonstrate to learners how to draw the box and whisker diagram. She indicated that she chooses the resources that are available or that she can easily get.

She also said she chooses resources that enable learners to understand the lesson better and that allow her to deliver the lesson to the best of her ability. The teacher indicated that she chooses the resources that are in line with the CAPS curriculum. This displayed T1's PCK in terms of knowledge of curriculum as she displayed her knowledgeability of available materials and their purposes. T1 highlighted that she uses a variety of textbooks like Classroom Mathematics, Siyavula and the Maths Handbook and Study Guide as well as past examination papers. She said she chooses

textbooks for herself based on whether the textbook is CAPS compliant. With the help of the CAPS document, she checks if the textbook covers all the content required by the CAPS curriculum.

T1 also linked the quartiles to fractions from the previous grade (Gr. 9) and this, according to Ball et al (2008) is evidence of the teacher's KCC. T1 highlighted that learners could understand new concepts better if they had prior knowledge from previous grades, like the understanding of fractions and percentages. She indicated that the topic continues to Grades 11 and 12 and is examinable. This displayed her knowledge of curriculum as she was knowledgeable about the available textbooks and that they served the purpose as per CAPS requirements.

### **Knowledge of content and teaching**

KCT was evident in how T1 explained and delivered the lesson. She made sure that she had the attention of the learners before delivering her instruction, and used questioning as part of instruction in order to check their understanding. T1 demonstrated content knowledge as she unpacked the concept of the box and whisker. She explained the five number summary in depth. Krauss et al. (2008) state that, as well as simply understanding a concept, teachers should know how the concept is best explained.

T1 displayed KCT by using a teaching strategy that got the learners involved. Sequencing of content, identifying methods and procedures of teaching are all functions of KCT. When T1 finished explaining the concepts, she started asking the learners some questions. They were asked to come to the board one by one, starting from the front. T1 said the decision for her strategy was spontaneous. She said the learners must always be alert and prepared to answer questions. They should all be involved so that they would pay attention while she was teaching, knowing that she could call anyone to the board to demonstrate some problems. T1 said she just calls on any learner and sometimes changes her criteria for choosing them; for instance, she may concentrate on struggling learners, or on boys or girls, or decide on any other criteria.

Shulman (1987) regards teaching experience as a source of PCK. A lack of such experience might therefore also contribute to poor results in mathematics. T1 has 17 years of experience and she displayed adequate knowledge of PCK with regards to

KCT, she explained her content very well, engaged learners a lot in discussion and answered most of their questions.

### **Knowledge of content and students**

This knowledge is described as the knowledge of knowing content and knowing one's learners. A teacher should have knowledge of what tasks will be motivating and interesting to learners and easy for them to understand. This will help in the teacher's decisions and choices of tasks that will motivate learners, and will also help the teacher to identify errors that are common to learners. T1 displayed KCS during the pre-lesson interview as she already anticipated some misconceptions in the finding of quartiles using the formula, and in interpreting the box and whisker.

Ball et al. (2008) assert that the teacher needs to know what misconceptions learners may have about a topic and how they are going to react to certain concepts taught. During the lesson, T1 repeated asking questions about quartiles and skewness of the box and whisker plot, for example, 1) *How do you determine the lower quartile and upper quartile?*, 2) *Comment on the skewness of the data.* She said she was emphasizing these concepts based on previous experience of learners' misconceptions. She said she has observed over the years that learners struggle with these aspects and have misconceptions about quartiles. T1 highlighted that sometimes learners do not understand what a quartile is, they tend to confuse a quartile with a data item.

T1 indicated that when planning for a new group of learners she always tries to look back at the misconceptions of the previous groups and address those in teaching the new group. The learners also had a misconception regarding interpreting the box and whisker. One learner asked why the boxes are not equal in size if each box constitutes 25%. The learners expected to see that the distances between the quartiles were equal, not realising that 25% meant the number of data items in each quartile were equal. However, the teacher showed evidence of her KCS when answering the learner by giving another example of percentiles.

### **4.5.3 Teacher 1: Post-lesson interview analysis**

During the post-lesson interview, T1 highlighted that the purpose of the lesson was achieved, although not 100%. She said when you are in front of the class you depend on the answers given by the children, but you will only be sure that the purpose of the lesson was achieved after a formal assessment, for example, after you give them a test, then you can see to what extent the purpose of the lesson has been achieved.

T1 indicated that she thought the learners had learnt what she wanted them to learn, although she would only see if they understood the concepts when they wrote a test. In the lesson they showed that they understood because they were able to answer questions, but the problem with classwork was that since they were working together some would just be copying others, whereas a test would assess each learner's individual work. The teacher indicated that her decision on the choice of classwork was informed by her desire to make sure that the questions she chose for classwork would make each learner comfortable, since the class was comprised of slow and fast learners. This was evidence of the teacher's KCS as she selected suitable examples. She stated that when she chooses questions she makes sure that they are both higher order questions and lower order questions. This displayed her KCS. She demonstrated an understanding of content and students by the examples and tasks she selected. The examples were easy to understand, thereby motivating the learners, and T1 chose examples which demonstrated real life situations.

In summary, T1 displayed strong PCK which may be due to her experience, since she has been teaching for 17 years. T1 has 17 years of experience and she displayed adequate knowledge of PCK, she explained her content very well, engaged learners a lot in discussion and answered most of their questions.

T1 displayed that she had mastered her content of the particular topic despite the fact that she did not study a module in statistics at college. She explained her concepts thoroughly in a way that enabled learners to find the topic easy, as was evident from their classwork feedback. T1 displayed KCT as her lesson was well planned sequentially from the known concepts to the unknown, using the requirements from the CAPS document. KCS was partially evident, as she could not adequately correct the learners' misconception when interpreting the box and whisker plot. Learners still could not understand what was meant by spread of data.

## 4.6 Lesson observation of Teacher 2 [School 2]

### 4.6.1 Teacher 2: Description of lesson

Teacher 2 indicated that the purpose of the lesson was to reflect and revise the five number summary, to represent the five number summary on a box and whisker and to interpret the box and whisker. T2 displayed his KCS during the pre- lesson interview as he highlighted that he anticipated that the learners would have a misconception in finding the quartiles. He said learners showed misunderstanding of quartiles, thinking the position of a particular quartile is the quartile itself. He also said that learners do not have a thorough comprehension of fractions from lower grades so they get confused easily. This also displays T2's knowledge of content and curriculum (KCC) as he could link lower grade concepts to this topic. The teacher indicated again that the learners also had misconception and difficulty in commenting on the skewness of the box and whisker.

#### Topic: Box and Whisker Plot

The lesson started at 09:00. The school was very close to my school. I had permission from the school principal to go and observe the lesson during my free periods. There was no disturbance of teaching and learning done. There were 34 learners in the classroom. The concepts to be taught were sketching of the box and whisker plot and interpreting it. T2 started the lesson by recapping on the five number summary. There was enough space in the classroom to allow him free movement. The learning environment was very conducive as there was enough furniture and enough space in the classroom. The school was well-resourced in terms of buildings and textbooks.

**Table 5: Lesson observation Teacher 2**

Lesson observation description	Analysis of lesson using PCK characteristics
<b>Introduction</b> 09:00-09:10 T2 asked the learners to open their textbooks on page 316 Ex. 8.7 No. 1. for the example. He asked learners what the five number summary consisted of and learners chorused answers as the teacher wrote on the chalkboard.	<b>Knowledge of content and teaching (KCT)</b> T2 displayed a characteristic of KCT as he started the lesson by finding out what the children already knew about the measures of central tendency. He asked simple questions like what is the maximum value, minimum, median and mean in a given data set.

<p>He read the question for the learners.</p>	
<p><b>Lesson development</b> 09:10-09:30 T2 explained the box and whisker as a diagrammatic representation of the five number summary. He read the question for the learners: 'Find the five number summary for the data items'. He used the lecture method and did most of the explaining and talking whilst learners listened. He told learners that they would do two examples from the textbook: page 316 Exercise 8 number 7, page 316 number 1 and lastly question 1 from the class test written previously. T2 wrote the example on the chalkboard.</p> <p><b>Step 1: finding five number summary</b> T2 explained that the five number summary consists of the minimum value, lower quartile, median, upper quartile and maximum value. He emphasized that the learners must arrange the entries in the data set in ascending order first before writing down the five number summary even if it was not asked in the question. He asked the learners the values of the five number summary of the example, taking them from the data set given. The learners chorused out the minimum and maximum values as T2 wrote on the chalkboard.</p> <p><b>Step 2: finding quartiles</b> T2 explained how to find the quartiles using formulae to find the position of the quartiles. Position of <math>Q_1 = \frac{n+1}{4}</math> <math display="block">\text{Position of } Q_2 = \frac{n+1}{2}</math><math display="block">\text{Position of } Q_3 = \frac{3(n+1)}{4}</math> He discouraged learners from finding the median by using their fingers from end to end and meeting in the middle, justifying this by asking 'What will you do if you have many data entries, like 100 entries?' He said it is easier to use the formula. He explained that when they used the formula what they got was not the values of the quartiles, but the positions of the quartiles. Once they got the position of the quartile, they simply had to go to the data set and find the value at that position.</p>	<p><b>Knowledge of content and teaching (KCT)</b> T2 showed characteristics of KCT by the way he sequenced his lesson in order for the learners to understand before taking them to the deeper content of interpreting the box and whisker plot and problem solving. He started by explaining what the box and whisker is and that they needed the five number summary first. He even used an instructional strategy of lecturing first so that he could explain all the concepts first before engaging the learners in activities. T2 also displayed KCT by using the chalkboard so that all learners could see as he was demonstrating the sketching of the box and whisker.</p> <p><b>Knowledge of content and students (KCS)</b> When T2 was explaining the quartiles, he reminded the learners that the formula for quartiles was used to find the position of the quartile. This shows that he displayed KCS because he anticipated that some learners were going to write the position as the quartiles. He already knew the misconceptions of the learners in this concept, that's why he reinforced the concept.</p> <p><b>Knowledge of content and curriculum</b> T2 displayed KCC as he referred to a policy document for which concepts to teach. He also used a textbook and recent past examination papers that are CAPS compliant. T2 displayed knowledge of the curriculum when he linked Grade 9 work on fractions with quartiles. He also displayed KCC by first revising fractions with the learners so that they could understand the quartile. He asked the learners about a quarter, half and three quarters, linking that to quartiles, showing them that the data set would be divided into four parts.</p>

**Step 3: Drawing the box and whisker**  
T2 said that once the learners got the five number summary, the next thing to do was to represent it in a box and whisker diagram. He then demonstrated on the chalkboard how to draw the box and whisker diagram. He told the learners that they must draw a number line with a suitable scale first. He then drew the box and whisker as the learners were chorusing the five number summary for the teacher. T2 emphasized the importance of labelling the box and whisker diagram.

**Step 4: Commenting on the box and whisker**  
Comment on the distribution/skewness of the data.  
The teacher explained that the learners must be able to comment on the distribution of data on the box and whisker diagram. He said the learners must state whether the box and whisker was symmetrically distributed, skewed to the left or skewed to the right. He explained that they should look at the whiskers and the box. In the example used the whisker was longer on the right, so he said it meant the box and whisker was positively skewed.  
On the other hand, he told the learners that if they were not convinced by that method, they could compare the mean and median to do the commenting.  
He asked them the distribution if:  
(a) mean = median and the learners chorused that it would be symmetrically distributed.  
(b) mean > median and the learners were not sure; they said negatively skewed. The teacher said "haaa" and the learners changed their answer, the teacher said "haaa" again and the learners changed the answer again, showing that they were not sure of what they were saying. The learners were just guessing, which the teacher noticed. He then assisted them.  
(c) mean < median, there was only one answer left so it was easy for the learners to chorus out that answer, but they were evidently not understanding what they were saying.

**Example 2: Class test Question 1**  
The teacher did the second example from the class test Question1.

T2 showed a characteristic KCT when he used another method to comment on the box and whisker diagram. Instead of just looking at the whiskers and the box, which might have confused the learners, T2 also used the strategy of comparing the mean and median. The various solution methods used by the teacher is indicative strong PCK.

<p><i>Question:</i> A group of 19 learners attending extra Physical Sciences classes wrote a test which was out of 50. The results were 5; 12; 13; 15; 18; 18; 18; 19; 20; 21;21; 22; 23; 23; 26; 29; 33; 35; 37.</p> <p>He again reminded the learners about arranging the data first.</p> <p><i>Draw a box and whisker.</i></p> <p>T2 explained that the learners should start by finding the five number summary even if they were not asked to do so.</p> <p>He repeated the process as above, again using the lecture method. Any question asked by the teacher was answered by the learners in a chorusing manner.</p> <p>Step 4: Class activity Page 317 No. 3</p> <p>T2 gave the learners some classwork to do and he monitored individuals, assisting those who had problems.</p> <p>He marked the learners' books as he was supervising the classwork.</p>	
<p><b>Conclusion</b> 09:30-09:35</p> <p>T2 concluded the lesson using the question and answer method. He asked learners some questions in summarising. He ended the lesson by asking if there were any questions and learners said they did not have questions. He then gave them homework.</p>	<p>T2 displayed KCS as he chose tasks that learners were suitable for his learners. He chose tasks with questions that were similar to the examples he did in class so that the learners could be motivated.</p>

#### 4.6.2 Teacher 2: Lesson analysis

##### Knowledge of content and students (KCS)

T2 displayed KCS as he was explaining the quartiles; he reminded the learners that the formula for quartiles was used to find the position of the quartile. He already knew the misconceptions of the learners regarding this concept, that's why he repeatedly explained that the position of the quartile is not the quartile itself.

T2 also displayed his KCS in anticipating that the learners would have a misconception in finding the quartiles, as he had already highlighted in the pre-lesson interview. The learners showed a misunderstanding of quartiles, they thought the position of a particular quartile was the quartile itself. T2 managed to explain well and emphasize

that the position is not the actual quartile. He said learners do not have a thorough comprehension of fractions because they get confused easily.

The teacher highlighted that learners also had misconceptions when commenting on the box and whisker. He said if they saw a long whisker, they thought they were working with many data entries. T2 enabled the learners to understand by explaining the spread of data. He constantly asked the learners about the position of the quartiles. He said when working with many data entries it becomes difficult to pick the lower or upper quartile, therefore it is better to use the formula position of lower quartile =  $\frac{n+1}{4}$ . He indicated that learners sometimes think the position is the lower quartile. On the other hand, T2 displayed limited KCS because the misconceptions of the learners were not fully addressed, since he did much of the talking. This meant that the learners were not given a chance to ask questions, express themselves and think critically. T2 assumed they understood, but they were just chorusing answers, which did not give the learners the opportunity to think in a critical way. The learners were not involved in class discussions, which would have helped T2 to develop knowledge of his learners' difficulties.

### **Knowledge of content and teaching**

T2 displayed KCT when he started the lesson because he ensured that the learners knew how to calculate the median of the data. The focus of the learners was on the teacher as he did most of the talking and the learners were listening. They responded to him, but in a chorusing manner. However, T2 said chorusing is not part of his approach, it just happens. He indicated that it is not really a good approach as it gives you as the teacher an impression that all learners are following, yet some are not and some will even be quiet. The teacher encouraged the learners to raise their hands. He did this as he marked the classwork, helping individual learners. He used the lecture method and said it was effective as he could cover more content using it. KCT was evident when he explained the procedure of drawing the box and whisker diagram. He also used the chalkboard so that the learners could all see what he was demonstrating. T2 said he chose his methods of teaching based on the different levels of understanding of the learners. He said you cannot just use explanation or the lecture method; he also used classwork assessment in order to check if his learners understood. He used worksheets as one of his instructional strategies because the

questions came from past examination papers and learners could become familiar with how questions are asked in exam format. He indicated that the questions from past examination papers are sequenced according to the cognitive levels in the policy document. He said the questions are sequenced from low order questions to high order questions.

T2 believed that his strategies were effective because many learners were able to answer the questions given. He displayed his KCT by the way he sequenced his lesson. He explained, step by step, the procedure to follow if one wants to draw a box and whisker plot. He also provided suitable examples that were CAPS compliant. T2 showed that he had knowledge that is unique to teaching by showing different methods to comment on the box and whisker diagram. He explained that the learners could comment using the box and the whiskers or they could compare the mean and the median (explained in table 5). This is supported by Ball et al. (2008, p. 399) who assert that teacher knowledge should go “beyond that of the children”. This knowledge was evident when the learners were not sure how to comment on the box and whisker and T2 decided to use another method of comparing the mean and median to comment.

### **Knowledge of content and curriculum**

T2 said he uses past examination papers for assessing his learners to check if they have understood the concepts taught, because the examinations papers link to the syllabus. He said he wanted his learners to get used to the way the questions are asked in examinations. He said the problem with sticking to textbooks only is that, in terms of cognitive demand, textbooks have mostly level 1(knowledge) and level 2 (routine) questions, so learners must be exposed to questions with different levels of cognitive demand by using past examination papers. According to the CAPS (DBE, 2011), mathematics assessments must be done on four cognitive levels.

T2 gave the learners classwork to do individually. He said they learnt what he wanted them to learn because they were able to draw and interpret the box and whisker diagram. The teacher said the learners needed prior knowledge of fractions from previous grades for them to understand the quartiles. The topic linked to Grade 9 fractions and also linked with Grade 11 as they would continue with the same concepts. The teacher said Grade 10 served as a foundation for the knowledge needed in future grades in FET mathematics. Ball et al. (2008) assert that teachers

must know the connections of the concepts they are teaching to those taught in lower and higher classes. T2 displayed this knowledge by linking quartiles to Grade 9 fractions; this displayed his PCK characteristic of knowledge of curriculum.

I watched the video with T2 and he indicated that he learnt something from it. He said he noticed things that he does and says unconsciously during the lesson that he could rectify after having observed them. For example, he noticed that he was facing the chalkboard a lot while talking, as he was writing on the chalkboard. He said that he also contributed to the misconception of the formula for finding positions of quartiles, as he heard himself saying 'Q1 equals' without saying 'position'. The teacher also commented that as he viewed the video he realised that he did not engage his learners a lot, and thus did not give them the chance to ask questions. He said he realised that he also needed to make them discuss amongst themselves by doing group work.

#### **4.6.3 Teacher 2: Post-lesson interview analysis**

T2 believed that the purpose of the lesson was achieved because of the correct responses of learners while doing classwork. He displayed KCT in the way his concepts were well-sequenced when he explained how to draw the box and whisker. He explained it step by step and it was easy for the learners to follow.

The majority of the learners were able to find the five number summary and draw the box and whisker. They were also able to interpret it.

T2 used textbooks for classwork examples and individual classwork assessment, and worksheet examples for homework. The chalkboard was used during the lesson to write notes and demonstrate how to draw the box and whisker plot. T2 used worksheets to assess for homework. He said his decision to use the chalkboard was so that every learner could see what he was demonstrating, drawing and writing. T2 also highlighted that he used textbooks so that the learners could work individually.

In summary, T2 demonstrated more of KCS and KCC than of KCT. He used the lecturing method of teaching, thereby not giving his learners a chance to pose questions or to discuss amongst themselves. He displayed KCS when he demonstrated his knowledge of the learners' misconceptions and difficulties. He tried to address the learners' difficulty in commenting on the box and whisker plot, but did not fully address the problem of interpreting the box and whisker. He did not give learners problem-solving questions. KCC was also evident with T2 having thorough

knowledge of the requirements of the CAPS curriculum on the topic and its link to the previous and future grades. KCT was partially demonstrated, as he did not use a variety of instructional strategies to motivate the learners. KCT was evident when he demonstrated how to draw the box and whisker diagram on the chalkboard.

## 4.7 Lesson observation of Teacher 3 [School 3]

### 4.7.1 Teacher 3: Description of lesson

The lesson started at 15:00 and there were 25 learners in the class. However, T3 said that there were altogether 52 Grade 10 mathematics learners in the school.

This was an extra lesson after school that was meant for me as researcher to observe. The purpose of the lesson was to draw the box and whisker plot and interpret it. The teacher highlighted that he would also revise fractions so that it will be easier when doing quartiles.

#### Topic: Box and Whisker Plot

**Table 6: Lesson observation Teacher 3**

Lesson observation description	Analysis of lesson using PCK characteristics
<p><b>Introduction</b> 15:00-15:10 T3 started the lesson by recapping on measures of central tendency. He asked learners about the mean, mode, median from Grade 9 knowledge. Teacher also recapped on fractions.</p>	<p><b>Knowledge of content and curriculum</b> T3 displayed a characteristic of KCC as he started the lesson by finding out what the children already knew from Grade 9. This was also evidence of knowledge of curriculum.</p>
<p><b>Lesson development</b> 15:10-15:25 T3 analysed the components of the box and whisker and stated the five number summary needed to draw the box and whisker. He wrote the example on the chalkboard.</p> <p>Step 1: Finding the five number summary. T3 explained that the five number summary consists of the minimum value, lower quartile, median, upper quartile and maximum value. He reminded the learners</p>	<p><b>Knowledge of content and teaching</b> T3 showed characteristics of KCT by the way he sequenced his concepts in order for them to understand concepts before taking them to the deeper content of interpreting and problem solving. He explained what the box and whisker and five number summary are, sketching them before commenting, which made it easy for the learners to follow. The teacher used the instructional strategy of lecturing. He also displayed KCT as he used the chalkboard so that all learners could see as he was writing notes,</p>

that they must arrange the entries in the data set in ascending order first, before writing down the five number summary. He wrote the five number summary on the chalkboard.

**Step 2: Finding quartiles.**

T3 explained how to find the quartiles without using the formula. He started with 3 numbers, then 4, then 5 until he gave many values. He explained that the learners must find the median first. He explained that if there are two numbers in the middle of the data set, they should add them and divide by two.

**Step 3: Drawing the box and whisker.**

T3 demonstrated on the chalkboard how to draw the box and whisker diagram. He told the learners that they must draw a number line with a suitable scale first. He then drew the box and whisker.

**Step 4: Commenting on the box and whisker.**

T3 explained that the learners must be able to comment on the distribution of data in the box and whisker diagram. He said the learners must state whether the box and whisker was symmetrically distributed, skewed to the left or skewed to the right. He explained that they should look at the distance between the median and the maximum value and the median and the minimum value. He told the learners they could compare the mean and median to comment.

(a) mean = median: symmetrically distributed.

(b) mean > median: positively skewed.

(c) mean < median: negatively skewed

T3 did a second example.

**Step 4: Class activity.**

T3 gave the learners some classwork to do and he monitored individuals, assisting those who had problems. He marked the learners' books as he was supervising the classwork, although his supervision was minimal.

demonstrating the sketching of the box and whisker.

**Knowledge of content and students**

T3 displayed KCS because he tried to make the learners understand the concept of quartiles by explaining on the median as the key factor to understand quartiles. T3 also displayed KCS by first revising fractions with the learners so that they could understand the quartile. He asked the learners about a quarter, a half and three quarters linking them to quartiles to show that the data set would be divided into four parts.

T3 displayed KCS as he defined the median and quartiles well to the learners. He also explained the content of the five number summary in an easily understandable manner.

T3 showed a characteristic knowledge of content and teaching when he used two methods to comment on the box and whisker diagram. He included the method of comparing the mean and median.

**Conclusion**

T3 concluded the lesson by summarising the key concepts. He asked learners some

KCS was displayed by the teacher as he gave them homework from past examination

questions in summarising. He gave the learners homework.	papers which were not challenging to the learners. The teacher chose the questions which were similar to what they did in class.
--	--

#### **4.7.2 Teacher 3: Lesson analysis**

##### **Knowledge of content and curriculum**

T3 displayed his knowledge of content and curriculum firstly by indicating that he uses the Annual Teaching Plan (ATP), which he referred to as his “bible” when teaching mathematics. He said the ATP is based on the CAPS document and it guides him on the appropriate content to teach. He also displayed his KCC by referring back to Grade 9 basics on fractions in particular quarters when he defined quartiles. He explained to learners that the word was derived from one quarter, which is something divided by four. Ball et al. (2008) assert that teachers must know the connection of the concepts they are teaching to lower and upper classes. This teacher displayed this knowledge by linking quartiles to Grade 9 fractions, and also recognising that it would help in Grade 11 when moving to percentiles. T3 displayed KCC, as he knew well how his resources were useful for him in his teaching. Shulman (1986) states that teachers must know what a curriculum entails. They must know the requirements needed to deal with a certain topic and have good PCK to arrange concepts in a way that will not confuse learners. T3 showed an understanding of the curriculum because he decided to link the concepts of the quartiles to learners’ previous knowledge of fractions in order to lead to a better understanding.

##### **Knowledge of content and teaching**

T3 used the chalkboard so that all learners could see as he demonstrated how to draw a box and whisker. The use of the chalkboard helps a teacher to gain the attention of the learners. T3 also used textbooks for his learners to write classwork. The teacher displayed his KCT as he properly sequenced his lesson and was able to respond to learners’ questions without difficulty. A learner asked why they are called quartiles and T3 showed his content knowledge by answering that the word came from a quarter, which is something divided by four; that is why in the box and whisker the data was divided into four parts. T3 believed that his strategies were 90% successful in his teaching because many learners were able to answer the questions given.

## **Knowledge of content and students**

T3 demonstrated content knowledge as he explained the five number summary. He showed a strong degree of knowledge of the topic as he explained it right from the start. He demonstrated an understanding of content and learners by the examples and tasks he selected. The examples were easy to understand, thereby motivating the learners, and T3 chose examples that demonstrate real life situations.

T3 also displayed KCS as he anticipated that the learners would have a misconception in finding the median and commenting on the skewness of the box and whisker. The learners showed misunderstanding of quartiles as well. T3 indicated that the median is the key concept, showing his content knowledge by emphasising the median. He displayed his content knowledge by defining the median first. He said learners do not have a thorough comprehension of fractions and get confused easily, therefore, in the introduction, T3 tried to cover fractions. Ball et al. (2008) describe horizon knowledge as teachers having an overall picture of the concepts they teach. As T3 had anticipated, the learners also had a misconception when commenting on skewness in the box and whisker (distribution of the data).

### **4.7.3 Teacher 3: Post-lesson interview analysis**

T3 indicated that he believed that his learners learnt the key concepts of the lesson. However, he said he would be sure when they wrote a test individually. He highlighted that he catered for errors and misconceptions by going back to Grade 9 basics, median mode and fractions. This was evidence of his KCC. T3 also displayed KCT as he highlighted that, in his experience, his strategies were effective because his learners score many marks in the box and whisker section of tests. He said when his learners are assessed with a class test in statistics they get higher marks for it when compared to tests in other topics. The teacher also said over his years of teaching, he has noticed that learners' misconceptions are the same.

I watched the video with T3 and he indicated that he learnt something from it. He noticed that in his teaching he was not energetic; he said he lacked enthusiasm in his way of teaching, which made the lesson uninteresting to the learners.

T3 also said he uses past examination papers and a textbook to reinforce what has been prepared. When the teacher was using past exam papers, he explained to learners how they could score marks easily in Paper 2 on statistics as he explained

the levels of questions. The teacher sequenced the questions from lower order to higher order questions. He said that the school is supportive as there are enough textbooks in the school. The Platinum Mathematics, Grade 10, is the available textbook. He said technology helps in that soft copies of the textbook are also available, which assists learners as they can have their own copies on their cell phones.

T3 indicated that the purpose of the lesson was to reflect and revise the five number summary, to represent the five number summary in a box and whisker diagram, and to interpret the box and whisker. He concluded that the purpose was achieved because of the correct responses of learners when doing classwork. He said the majority of the learners were able to find the five number summary and draw the box and whisker and they were also able to interpret it. T3 said his decision to use the chalkboard was so that every learner could see what he was demonstrating, drawing and writing. He highlighted that used textbooks so that the learners could work individually.

T3 said he wanted the learners to be able to find the median, upper quartile, lower quartile, minimum and maximum values so that they could draw a box and whisker. He said that believed he achieved what he wanted to achieve, although on the learner's side he would only know when they had written a test. He said he did not want to rate them with classwork because some learners just copy from those who have understood and they are scared to ask where they do not understand.

T3 said he decided on the resources he used because that was what was available in the school. He said these resources were 90% successful in his teaching.

In summary, T3 displayed all three categories of PCK, especially KCC and KCS. KCT was only slightly evident as the teacher was very passive and his way of presenting the concepts was not very motivating to learners. His voice was very low and he was the one talking the most during the lesson and writing on the chalkboard. He was asking questions and answering them himself, without giving the learners the chance to answer. He demonstrated KCS by his introduction of the lesson where he recapped on prior knowledge. He also used classwork assessment to check on the learners' misconceptions and difficulties as he marked the books. His KCC was displayed when he linked quartiles to Grade 9 fractions.

## **4.8 Conclusion**

This chapter explained the demographic profiles of the participants. It described the lesson observations and semi-structured interviews. The data obtained from the observations and interviews were presented, and analysed according to Ball et al.'s (2008) framework. The next chapter compares the key similarities and differences between the practices of the three teachers. It also presents discussions and recommendations.

# CHAPTER 5: DISCUSSION OF FINDINGS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter aims to summarize and discuss the findings of the study, which aimed at exploring the pedagogical content knowledge of three FET mathematics teachers at Grade 10 level. The chapter will show if the research questions were addressed and achieved. The chapter will also highlight the similarities and differences in the findings of the study on the PCK of the participant teachers, based on Ball et al.'s framework. The research questions for the study were:

1. What pedagogical content knowledge do FET teachers show in their teaching of mathematics?
2. What is the relationship between the teachers' pedagogic decision-making and PCK?

## 5.2 RQ1: What pedagogical content knowledge do FET teachers show in their teaching of mathematics?

The following section provides a summary of the findings based on Ball et al.'s (2008) framework.

### 5.2.1 Knowledge of content and students (KCS)

Ball et al. (2008) assert that KCS (knowledge of content and students) involves understanding common errors and misconceptions made by learners, and interpreting learners' mathematical thinking. It was evident from what the teachers anticipated that the learners' main misconceptions were thinking that the position of a particular quartile is the quartile itself, and also in interpreting the box and whisker plot some learners thought the bigger the box, the more data entries in that quarter. The strengths of the learners were in stating the five number summary and drawing the box and whisker diagram. Learners were also good at reading the five number summary from the box and whisker plot.

The study showed that T1, T2 and T3 all had knowledge of content and students. The three teachers had an insight on how learners think about the box and whisker plot, which made it possible for them to expect learners' thinking. During pre-lesson observation interviews and post-lesson observation interviews, all three teachers explained clearly the misconceptions they anticipated learners having regarding the topic. They all cited the same common misconceptions of quartiles, commenting on the box and whisker diagram and interpreting it. Thus all three teachers showed evidence of KCS.

However, they differed slightly in the ways they corrected the misconceptions. On the misconception of quartiles, they had the same notion that they could redress the situation by recapping on fractions from Grade 9. T3 even indicated that he told learners that the word quartile comes from quarter, which is something divided by four. T1 and T2 both used the formula for finding  $Q_1$ ,  $Q_2$  and  $Q_3$  by finding the position first. That was the part where learners were confused, thinking that the position was the actual quartile. Both T1 and T2 said they corrected it by continuously telling the learners that the position was not the actual quartile. T3 said he did not use the formula to avoid this misconception, since he had discovered that the learners kept on making the same mistake. He said he only uses the formula with bright learners.

T1, T2 and T3 also talked about learners' misconception in commenting on the box and whisker. None of the three teachers explained in greater depth about the spread of data. As a result, the learners were still getting lost, and did not understand what was meant by the spread of data, but the teachers just continued teaching. T1 and T2 ended up teaching another method of comparing median and mean in order to comment on the skewness of the box and whisker, and learners just had to cram it and then comment, without actually understanding the reasoning behind it. This was evidence of limited knowledge of content and teaching on the part of all three teachers of how to redress learners' thinking.

T1 and T2 displayed KCS in the way they started their lessons by recapping prior knowledge and work on measures of central tendency done during the previous grades and previous lesson. This was done by asking questions to learners. T1 just pointed at any learner to come to the chalkboard and write answers. T3 also recapped on the previous lesson and started teaching the lesson for the day. T3 did not engage

his learners a lot. Since T3 does not have a teaching qualification, he does not have the pedagogical knowledge of teaching mathematics.

### **5.2.2 Knowledge of Content and Teaching (KCT)**

KCT involves knowledge of content and teaching. Teachers need to understand how to represent mathematical concepts, sequence content, select examples, and explain methods and procedures. From the lesson observations, it was discovered that all three teachers had almost the same instructional strategy of teaching the topic by lecturing on it.

McTighe and Seif (2003) contend that teachers should create situations that allow learners to ask questions and work together, so that they can communicate amongst themselves and also develop problem solving techniques. Since the teachers mostly used the lecture method where they did most of the talking, they did not give the learners a chance to do group work where they could discuss and explain to each other how they arrived at their solutions.

T1, T2 and T3 all started their lessons by recapping the previous lesson. T1, T2 and T3 all had more or less similar strategies in teaching this topic although T1 employed a strategy where she interacted a lot with the learners and engaged them. The researcher assumed that maybe it was because of the nature of the topic, according to the requirements of the sequence stipulated by the ATP. They all used the lecture method most of the time, which means that they did more talking whilst learners were listening. T2 and T3 did not engage their learners a lot, whereas T1 made her learners participate throughout the lesson, and come to the chalkboard to present their solutions. T2's learners engaged in a lot of chorusing, although he indicated that it was not one of his instructional teaching strategies, it was just something that happened. He admitted that it was not a very good instructional strategy because as the teacher you might think all the learners are following, yet others are quiet, not knowing anything. T3 did not engage learners a lot; most of the time he was just explaining. T1 engaged her learners using a lot of questioning technique to make a follow-up to check whether the learners understood or not, which showed evidence of her knowledge of content and teaching.

T1 has 17 years of teaching experience and this could have contributed to her deep knowledge of instructional strategies, apart from just lecturing to learners. T2 and T3 used a lot of lecture method.

One strategy that was most evident with all three teachers was the use of the chalkboard. T1 explained that she used it because that was what was available. The school did not have sufficient resources like enough textbooks, so she was writing the questions on the chalkboard. T2 said he used the chalkboard so that all the learners in class would be able to see when he was demonstrating, drawing or working out a problem. T3 indicated that he used what was available. All three teachers also observed that they used textbooks as one of their strategies of teaching. The textbooks were used for classwork activities. T2 even had additional worksheets for homework.

The three teachers sequenced their lessons in a way that could make it easier for learners to follow, thereby indicating their KCT. They all started by recapping on the previous lesson and checking on prior knowledge using questioning techniques. All three teachers gave stage-by-stage explanations on drawing the box and whisker plot, starting with the five number summary. Teacher 1 demonstrated on her own first how to draw the box and whisker, but she asked learners to come to the chalkboard to write the five number summary. Learners were not given the chance to raise up their hands she was just pinpointing as she said every learner must be prepared to answer questions. Teacher 2 also explained how to find the five number summary and demonstrated how to draw the box and whisker plot on the chalkboard. The learners were just listening and copying what the teacher was writing. Teacher 3 also just explained the stages to follow when drawing a box and whisker plot.

Teacher 1 and teacher 2 also used the strategy of checking the learner's work and marking as the lesson was in progress, which assisted them to identify the learners' misconceptions and difficulties. On the other hand, T2 said he didn't want to rely too much on classwork as it did not give a true reflection of the learners' understanding since some would just be copying the work from other learners. He said he would only see after they wrote a test if they had understood.

Most learners had difficulties in interpreting and commenting on the box and whisker diagram. They also could not use proper scaling. T1 indicated that she uses extra

tutoring for those learners who are still experiencing difficulties. All three teachers also used drill and practice strategy for the learners to have more practice.

T1 discovered her learners' errors and difficulties when the learners were coming to the chalkboard. She tried to respond to these errors by giving them alternative methods, for example, for interpreting the box and whisker plot she gave them two different methods that gave the same answer. She also responded by using the learners' home language to again explain the concepts. T1 also tried to address the difficulties by arranging extra lessons for those who did not understand so that she could explain the concepts again. T2 and T3 discovered their learners' difficulties as they were marking exercise books on the classwork given. T1's strategy of involving learners a lot made learners expose their difficulties and this was evidence of her KCT. All three teachers managed to identify the learners' errors and could explain things to them so as to break down those misconceptions, including by giving them alternative methods. This displayed the teachers' KCT.

In summary, it was evident that the three teachers taught this topic in almost the same way. All the teachers used the lecture method, although T1 engaged learners a lot, while T2 and T3 were mostly talking. This may be due to them having fewer years of experience. "Successful teachers are those who are able to use a range of teaching strategies and who use a range of interaction styles, rather than a single, rigid approach." (Rajendran et al., 2006, p.1)

The three teachers all used the chalkboard, but for different reasons. All three teachers used textbooks for classwork assessment, while T2 had additional worksheets which he said helped him to put more questions together that covered various cognitive levels, so that the learners got used to examination type questions. The three teachers are from the same circuit but I do not think this contributes to their similar teaching approach, because no teacher development workshop had been done on that particular topic. Batanero et al. (2011) contend that there are very few teachers with pedagogical training in statistics. Teachers often use the traditional approach in statistics where formulae are used and calculations are performed, instead of using real data to explain principles in statistics, procedures and reasoning (North, Scheiber & Ottaviani, 2010). Ball et al. (2008) assert that teachers need to know the topics they should teach and the plan of action required to teach those topics in statistics.

### 5.2.3 Knowledge of Content and Curriculum (KCC)

The three teachers displayed KCC, as they had knowledge of the content that they were required to cover in Grade 10 statistics, that is, the five number summary (maximum, minimum and quartiles) and box and whisker diagram, and using the statistical summaries (measures of central tendency and dispersion) and graphs to analyse and make meaningful comments on the content associated with the given data. All three displayed KCC as they had relevant tasks in accordance with the CAPS curriculum and their tasks covered the four cognitive levels required by CAPS, that is, level 1 (knowledge questions like recalling), level 2 (routine questions), level 3 (complex procedure questions) and level 4 (problem-solving questions).

Over seventeen years of teaching, T1 has gained her knowledge of content and curriculum in teaching statistics through her involvement in lesson planning using the ATPs, CAPS policy document and textbooks recommended by the Department of Basic Education. T2 and T3, although having less experience than T1, also demonstrated knowledge of teaching and curriculum, as they explained that they taught learners from a basis of prior knowledge and they knew how the topic was going to be extended to Grades 11 and 12. T3 had the ATP, which he explained is an extract from the CAPS policy document. All three teachers linked the topic well to previous grades and they could explain in the interviews how the topic linked to Grades 11 and 12. All three teachers used textbooks that are CAPS compliant, thereby indicating their KCC. They all teachers demonstrated a strong knowledge of curriculum, as they were able to teach the topic according to the requirements of CAPS. All three had knowledge of the arrangement of the topics in the year. All the teachers revealed KCC, as they used the CAPS document to prepare for the lesson.

In summary, all three teachers displayed their KCC as they all recapped on previous knowledge from Grade 9 on measures of central tendency. Then they followed stage by stage the sequence of drawing the box and whisker plot by finding the five number summary first.

**Table 7: Instructional strategies and resources used by participants**

Name of teacher	Name of school	Chalkboard	Textbook	Worksheets	Any technology
T1	S1	Yes	Yes	No	No

T2	S2	Yes	Yes	Yes	No
T3	S3	Yes	Yes	No	No

### **5.3 RQ 2: What is the relationship between the teacher’s pedagogic decision-making and their pedagogic content knowledge (PCK)?**

Research question 2 aimed to explore the relationship between the PCK of the teachers and their pedagogic decisions when teaching. Shulman’s (1986,1987) notion of PCK gives attention to the role of content when teachers make pedagogical decisions. According to Ball et al. (2008), a teacher’s mathematical knowledge for teaching (MKT) influences pedagogic decisions such as when to give a remark and redirect a learner, when to pose questions to further learners’ learning, and how to respond to learners’ mathematical remarks. The pedagogical decisions made by teachers influence learners’ performances.

Casey (2008) asserts that teachers need a type of knowledge that enables them to anticipate the ideas that learners have when they learn a certain topic so that they can make pedagogical decisions that will address those ideas. From the data collected from the teacher’s interviews, it was evident that the KCS of the teachers contributed to their pedagogic decision making. All three teachers planned their lessons using their knowledge of learners’ misconceptions, as they indicated in the pre-lesson interviews that they already anticipated misconceptions and difficulties in the quartiles, and commenting and interpreting on the box and whisker plot. So their lesson plans were planned ready to address those misconceptions. T2’s KCT also helped him to correct the misconception in commenting on the skewness of the box and whisker by using a different approach of comparing the mean and the median.

T2 said his learners have misconceptions when finding the quartiles using the formula. They are supposed to find the position of the quartile first, then they should locate that position from the data set given. So the teacher had planned his lesson ready to address this misconception by repeating and drilling the learners on the same concept. T3 decided not to use the formula at all to find the quartiles, since learners kept on making the same error. Instead, he said he decided to do it step by step, starting with a few data items, using three numbers, then four, then five and so on. On the other

hand, T3 failed to correct the misconception learners had when using the formula, which shows that he lacked KCT.

T1, T2 and T3's pedagogical decisions on the classwork and examples to use in the lesson were also informed by their knowledge of curriculum. They used examples that were related to everyday life, for example, data on heights of learners and this is important (Ediger, 2002). They all had the knowledge of how Grade 9 data handling and fractions linked to Grade 10 statistics, hence they all mentioned in the interviews that the learners needed prior knowledge of fractions from the previous grade for them to understand the quartiles and how these linked to Grade 11 and 12 work. However, on the issue of textbooks, T2 indicated that his decision for the textbook they were using was because that was what was available, so it was not informed by any category of his PCK.

T1's KCC influenced her decision to use textbooks, as she was well acquainted with the requirements of the CAPS policy document on the topic. T2's pedagogical decision on not using the textbooks a lot was guided by his KCC, as he pointed out during interviews that he does not rely a lot on textbooks since they have too many lower-level questions. He therefore chooses to give his examples and classwork mostly from past examination papers, since they follow exactly what is required by the CAPS curriculum. T3 indicated that his pedagogical decision on using textbooks is that he uses them to introduce topics and it is easier when he gives homework, textbooks explain concepts clearly. All the teachers displayed KCC as they were all teaching the topic at the correct time of the year in Term 3.

Casey (2008) states that teachers need the category of knowledge that combines their content of a particular topic and pedagogical ways of teaching it, that is, they need KCT. They need it when making pedagogical decisions, like the sequencing of content and how to represent it. KCT guided all three teachers in their decisions on structuring and sequencing their lessons.

All of them used the chalkboard. T1 indicated that her decision for using this resource was because the school does not have enough resources, like textbooks, so she needed the chalkboard to write the questions there so that every learner could see and copy from the chalkboard. This decision had no link to any category of PCK although she said the strategy worked for her. The DBE report (2012) indicated that

limited PCK in statistics may contribute to poor performance, so teachers need to design good teaching and learning strategies. Since the CAPS curriculum is structured and provides guidelines, the teachers also made applied decisions based on their knowledge of curriculum.

In summary, all three teachers' decisions on their teaching strategies were based on their KCS. All of them had good KCC, which led them to structure and sequence their lesson on the box and whisker as per CAPS requirements. In summary, the observations above indicate that there is a relationship between the teachers' PCK and their pedagogical decisions.

#### **5.4 Summary of findings**

The study indicates that all three teachers displayed all three categories of PCK during the lessons and interviews. The most evident category of knowledge they all displayed was knowledge of content and curriculum. The teachers strongly displayed this knowledge, especially through their knowledge of how the topic linked to the previous grade and to future grades. They mentioned this in the interviews. They were all using relevant textbooks that concur with the CAPS curriculum and they all had knowledge of sequencing the concepts as prescribed by CAPS.

The three teachers showed some aspects of KCS, although some of them lacked a way of effectively addressing some of the learner difficulties, especially in interpreting the box and whisker. All of them knew the misconceptions and difficulties of their learners, but they lacked enough KCT to explain to learners about the spread of the data on the box and whisker plot. Learners were looking at the sizes of the box and they thought the bigger the box, the more data entries there were in that quarter of the box. T2 displayed KCS in responding to that, as he managed to explain it in a way that learners understood. T3 told the learners that it would be part of their homework, indicating that he lacked enough content knowledge to give it an explanation.

Lastly, from observation it was evident that KCT is the category of PCK that the teachers still lack. The teachers did not display a strong degree of knowledge of how to represent their concepts.

## **5.5 Limitations of the study**

The study was restricted to three teachers in one circuit so the sample was small, which means that the results cannot be generalized beyond this sample of teachers. Time was the biggest research challenge as I teach Matric learners, which meant that my time was very limited due to the programmes that the department organised for Matric learners, like teaching extra time during weekends and holidays and attending workshops. I had to ask T1 and T3 to organise their lessons with their learners after school especially for this study. I also got my ethical clearance late and had to collect the data in Term 3 when teachers were very busy preparing for the end of year examinations. It was a challenge for me and the participating teachers to get enough time for this, since they also teach matric learners. So generally, there was not enough time for conducting the research fieldwork. Another limitation of this study is that only one lesson was observed per teacher.

## **5.6 Recommendations**

Content workshops on interpretation of the box and whisker need to be arranged by the subject advisors to try to improve teachers' knowledge on how to teach statistics. The workshops must provide information about learners' misconceptions and assist teachers to understand their learners' misconceptions. The workshops must help teachers with PCK, or strategies, approaches and ways which they can use to improve the teaching of the box and whisker plot and also statistics in general. Lemmer, Edwards & Rapule (2008) state that many mathematics teachers did not study statistics during their pre-service training. T1 even mentioned that she did not study a module on statistics during her tertiary education. Methodology workshops for teachers in statistics are also recommended to improve teachers' KCT. Teachers need to develop different methods in the teaching of statistics.

## **5.7 Conclusion**

The aim of this study was to explore the PCK of three Grade 10 mathematics teachers, and this chapter provided a summary of my findings and recommendations. The three teachers taught the same topic, that is, the box and whisker plot. They all taught it in almost the same way, maybe because the nature of the topic is that it is procedural. They displayed the three categories of PCK according to Ball et al. (2008), although

they struggled to help learners to understand the meaning of the spread of data. The pedagogic decisions of the teachers were based on their KCS and KCC, although some pedagogical decisions were based on the resources that were available for them. The teachers still lack KCT in this topic as they all presented their topic by lecturing. They did not display a variety of ways to illustrate and represent the concepts. All three teachers used the chalkboard quite well to demonstrate to learners how to draw the box and whisker plot. They also wrote their notes clearly on the chalkboard so that all the learners would have a full view. According to Anthony and Walshaw (2009), effective teachers use tools and representation to bring about effectiveness in their teaching. Each of the teachers gave classwork and homework at the end of their lesson to assess the learners. Finally, this chapter highlighted recommendations for further study in order to address the identified issues.

## REFERENCES

- Abell, S. K. (2007). Research on science teacher knowledge. In S. K. Abell & N. G. Lederman (eds.), *Handbook of research on science education*. (pp.1105-1149). Mahwah, N.J.: Lawrence Erlbaum.
- Adler, J. (2004). Researching inside teacher education: the QUANTUM project, its context, some results and implications. Paper presented at the AERA, San Diego.
- Adler, J., & Venkat, H. (2012). Coherence and connections in teachers' mathematical discourses in instruction. *Pythagoras*, 33(3), 1-8.
- Aliaga, M., Cobb, G., Cuff, C., Garfield, J., Gould, R., Lock, R. (2010). *Guidelines for assessment and instruction in statistics education: College report*, California: American Statistical Association.
- An, S., Kulm, G., & Wu, Z. (2004). The pedagogical content knowledge of middle school mathematics teachers in China and the U.S., *Journal of Mathematics Teacher Education*, 7, 145-172.
- Anthony, G., & Walshaw, M. (2009). Characteristics of Effective Teaching of Mathematics: A View from the West. *Journal of Mathematics Education*, 2(2), 147-164.
- Arends, F., Winnaar, L., & Mosimege, M. (2017). Teacher classroom practices and Mathematics performance in South African schools: A reflection on TIMSS 2011. *South African Journal of Education*, 37(3), 1-11.
- Bakker, A., Konold, C., & Biehler, R. (2004). Should young students learn about box plots? In G. Buriill & M. Camden (Eds). *Curricular development in statistics education. International association for statistical education 2004 round table*. Voorburg, the Netherlands: International Statistical Institute, (pp 163-173).
- Ball, D.L., Thames, M.H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, 59(5), 389-407.
- Bansilal, S. (2014). Using an APOS framework to understand teachers' response to questions on the normal distribution. *Statistics Education Research Journal*, 13(2), 42-57.
- Bansilal, S., Brijlall, D. & Mkhwanazi, T.W. (2014). An exploration of the common content knowledge of high school mathematics teachers. *Perspectives in Education*, 32(1), 34-50.
- Batanero, C., Burill, G., & Reading, C. (Eds). (2011). *New ICMI Study: Teaching Statistics in School Mathematics Challenges for Teaching and Teacher Education: A Joint/ IASE Study*, 14(1), 407-418.

- Ben-Zvi, D. & Garfield, J. (2004). *The challenge of developing statistical literacy, reasoning and thinking*. The Netherlands: Kluwer Academic Publishers.
- Bertram, C. (2011). What does research say about teacher learning and teacher knowledge? Implications for professional development in South Africa. *Journal of Education*, 52(5), 26.
- Bertram, C., & Christiansen, I. (2014). *Understanding research: an introduction to reading research*. Pretoria: Van Schaik Publishers.
- Brijlall, D., & Isaac, V. (2011). Links between content knowledge and practice in a mathematics teacher education course: A case study. *South African Journal of Higher Education*, 25(4), 680-699.
- Brijlall, D. (2014). Exploring the pedagogical content knowledge for teaching probability in middle school: A South African case study. *International Journal of Educational Sciences*, 7(3), 719-726.
- Brodie, K. (2014). Learning about learner errors in professional learning communities. *Educational Studies of Mathematics*, 85(2), 221-239.
- Brynard, D. J., Hanekom, S. X., & Brynard, P.A. (2014). *Introduction to Research*. Pretoria: Van Schaik Publishers.
- Carnoy, M., & Chisholm, L. (2008). *Towards understanding of student academic performance in South Africa. A pilot study of grade 6 mathematics lessons in South Africa. Report prepared for the Spencer Foundation*. Pretoria: HSRC.
- Carnoy, M., & Arends, F. (2012). Explaining mathematics achievement gains in Botswana and South Africa. *Prospects*, 42(4), 453-468.
- Carnoy, M., Chisholm, L., Addy, N., Arends, F., Baloyi, H., & Irving, M. (2011). *The Process of Learning in South Africa: The Quality of Mathematics Teaching in North West Province*. Cape Town: HSRC Press.
- Casey, S. A. (2008). *Subject matter knowledge for teaching statistical association*. Unpublished PhD Thesis, Illinois State University, Illinois.
- Centre for Development and Enterprise (CDE). (2011). *Value in the classroom: The Quantity and Quality of South Africa's Teachers*. Abridged Report on Research. Johannesburg: Centre for Development and Enterprise.
- Centre for Development and Enterprise (CDE). (2013). *Mathematics outcomes in South African schools. What are the facts? What should be done?* Research papers for CDE. Johannesburg: Centre for Development Enterprise.
- Chick, H.L. (2007). Teaching and learning by example. In J. Watson & K. Beswick (Eds), *Mathematics: Essential research, essential practice. Proceedings of the 30<sup>th</sup> Annual Conference of the Mathematics Education Research Group of Australasia*, p.3-21). Sydney, Australia: MERGA.

- Chick, H.L., & Pierce, R. (2013). The Statistical Literacy Needed to Interpret School Assessment Data. *Mathematics Teacher Education and Development Journal*, 15(2), 1-19.
- Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. (6<sup>th</sup> ed.). Abingdon, Oxon: Routledge.
- Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education*. (7<sup>th</sup> ed.). London. Routledge.
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education*. (8<sup>th</sup> ed.). London and New York: Routledge.
- Corbin, J. & Strauss, A. (2008). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (3<sup>rd</sup> ed.). Thousand Oaks, CA: Sage.
- Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed method approaches* (3<sup>rd</sup> ed.). Thousand Oaks, CA: Sage Publications.
- De Miranda, M.A. (2008). Pedagogical Content Knowledge and Engineering and Technology Teacher Education Issues for Thought. *Journal of Japanese Society of Technology*, 50(1), 17-26.
- Department of Education (2008). *National Curriculum Statements Grades 10-12 (General), Learning Programme Guidelines: Mathematical Literacy*. Pretoria: Department of Education.
- Department of Basic Education (2011). *Curriculum and assessment policy statement (CAPS): Mathematics Grades 10-12*. Pretoria: South Africa.
- Department of Basic Education (2012). *Diagnostic Report. Annual National Assessment*.
- Department of Basic Education. (2013). *Report on the 2012 National Senior Certificate. Diagnostic Report*. Pretoria: Government Printer.
- Department of Basic Education. (2015). *Report on the 2014 National Senior Certificate. Diagnostic Report*. Pretoria: Government Printer.
- Department of Basic Education. (2016). *Report on the 2015 National Senior Certificate. Diagnostic Report*. Pretoria: Government Printer.
- Department of Basic Education. (2017). *Report on the 2016 National Senior Certificate. Diagnostic Report*. Pretoria: Government Printer.
- Department of Basic Education. (2018). *Report on the 2017 National Senior Certificate. Diagnostic Report*. Pretoria: Government Printer.
- Department of Basic Education. (2019). *Report on the 2018 National Senior Certificate. Diagnostic Report*. Pretoria: Government Printer.

- Department of Basic Education. (2020). *Report on the 2019 National Senior Certificate. Diagnostic Report*. Pretoria: Government Printer.
- De Vos, A. S. (2002). *Research at grass roots for the social sciences and human service professions*. Pretoria: Van Schaik Publishers.
- Ediger, M. (2002). Quality teaching in mathematics. *Education*, 133(2), 235-239.
- Eysink, T.S., de Jong, T., Berthold, K. & Kolloffel, B., Opfermann, M., & Wouters, P. (2009). Learner Performance in Multimedia Learning Arrangements: An analysis across Instructional Approaches. *American Educational Research Journal*, 46(4), 1107-1149.
- Franklin, c., Kader, G., Mewborn, D.S., Moreno, J., Peck, R., Perry, M., & Scheaffer., R. (2007). *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K-12 Curriculum Framework*. Alexandria: American Statistical Association. Retrieved from [http://www.amstat.org/education/gaise/GAISEPreK12\\_Intro.pdf](http://www.amstat.org/education/gaise/GAISEPreK12_Intro.pdf)
- Garegae, K.G. (2008). Training statistics teachers for Botswana senior schools: is it necessary? In C. Batanero, G. Burrill, C. Reading & A. Rossman (Eds). *Proceedings of ICMI Study18 and 2008 IASE Round Table Conference*. ICMI/IASE.
- Garfield, J.B., & Ben-Zvi, D. (2005). A framework for Teaching and Assessing Reasoning about Variability. *Statistics in Education Research Journal*, 4, 92-99.
- Garfield, J., & Everson, M. (2009). Preparing teachers of Statistics: A Graduate Course for future Teachers. *Journals of Statistics Education*, 17(2).
- Gass, S. M., & Mackey, A. (2000). *Stimulated recall methodology in second language research*. Routledge.
- Grossman, P.L. (1990). *The making of a teacher: teacher knowledge and teacher education*. New York: Teachers College Press.
- Grossman, P.L., & Richert, A.E. (1988). Unacknowledged Knowledge Growth: A Re-examination of the Effects of Teacher Education. *Teaching and Teacher Education*, 4(1), 53-62.
- Groth, R.E., (2017). Developing statistical knowledge for teaching during design-based research. *Statistics Education Research Journal*, 16(2), 376-396.
- Hagreaves, A. (1994). *Changing teachers, changing times: Teachers' work and culture in the post-modern age*. New York: Teachers College Press.
- Hill, H. & Ball, D. (2009). The curious-and-crucial case of mathematical knowledge for teaching. *Phi Delta Kappan*, 91(2), 68-71.
- Hill, H.C., Rowan, B. & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, 42 (2), 371-406.

- Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education*, 39(4), 372-400.
- Hoadley, E. & Jansen, J. (2012). *Curriculum: Organizing knowledge for the classroom*. Cape Town: Oxford University Press.
- Hugo, W. Jack, M., Wedekind, V., & Wilson, D. (2010). The state of education in Kwazulu-Natal: A report to the Provincial Treasury. *Pietermaritzburg: KZN Provincial Treasury*.
- Kazima, M., Pillay, V., & Adler, J. (2008). Mathematics for teaching: Observations from two case studies. *South African Journal of Education*, 28, 283-299.
- Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education*, 45(2), 169-204.
- Kortenkamp, U., & Rolka, K. (2010). *Using technology in the teaching and learning of box plots*, (pp. 1070-1080).
- Krauss, S.E. (2005). Research paradigms and meaning making: A Primer. *The Qualitative Report*, 10(4), 758-770.
- Krauss, S., Baumert, J., & Blum, W. (2008). Secondary mathematics teachers pedagogical content knowledge and content knowledge. *Mathematics Education* 40(5), 873-892.
- Lampert, M. (1984). Teaching about thinking and thinking about teaching, *Journal of Curriculum Studies*, 16, 1-18.
- Lem, S., Onghema, P., Verschaffel, L. & Doreen W.V. (2014). Experts' Misinterpretation of Box Plots-a Dual Processing Approach. *Psychologica Belgica*, 54(4), 395.
- Lemmer, S., Edwards, J., & Rapule, S. (2008). Educators' selection and evaluation of natural sciences textbooks. *South African Journal of Education* 28(2), 175-187.
- Lowery, N.V. (2002). Construction of teacher knowledge in context: Preparing elementary teachers to teach mathematics and science. *School Science and Mathematics*, 102(2), 68-83.
- Lyle, J. (2003). Stimulated recall: a report on its use in naturalistic research. *British Educational Research Journal*, 29(6), 861-878.
- Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum.
- Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research*, 16(2), 193-205.
- Maree, K. (2007). *First steps in research*. Pretoria: Van Schaik Publishers.

- McTighe, J., & Seif, A. (2003). Teaching for meaning and understanding: A summary of underlying theory and research. *Pennsylvania Educational leadership*, 24(1), 6-14.
- Merriam, S.B. (1998). *Qualitative research and Case Study Applications in Education*. San Francisco, CA: Jossey-Bass.
- Merriam, S.B. (2009). *Qualitative research: a guide to design and implementation. Revised and expanded from qualitative research and case study applications in education*. USA: Jossey-Bass.
- Mishra, P., & Koehler, M. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *The Teachers College Record*, 108(6), 1017-1054.
- Morrow, W. (2007). *Learning to teach in South Africa*. Pretoria: HSRC Press.
- Muir, T., & Beswick, K. (2007). Stimulating reflection on practice: using the supportive classroom reflection process. *Mathematics Teacher Education and Development*, 8, 74-93.
- Nguyen, N. T., McFadden, A., Tangen, D., & Beutel, D. (2013). *Video Stimulated Recall Interviews in Qualitative Research*. Queensland University of Technology, Brisbane, Australia.
- North, D., Scheiber, J., & Ottaviani M.G. (2010). Training teachers to teach statistics in South Africa: Realities and Attitudes. In C. Reading (Ed.), *In Proceedings of the 8<sup>th</sup> International Conference on Teaching Statistics (ICOTS-8)*, Ljubljana, Slovenia.
- North, D. & Zewotir, T. (2006). Introducing statistics at school level in South Africa. In A. Rossman & B Chance (Eds.), *Proceedings of the Seventh International Conference on Teaching Statistics*, Salvador, Brazil: International Statistical Institute and International Association for Statistical Education. Online: <http://www.stat.auckland.ac.nz/-iase/publications>.
- Olivier, A. (1989). Handling pupils' misconceptions. *Pythagoras*, 21, 9-19.
- Perren, L., & Ram, M. (2004). Case study method in small business and entrepreneurial research: Mapping boundaries and perspectives. *International Small Business Journal*, 22(1), 83-101.
- Pfannkuch, M., & Ben-Zvi, D. (2011). Developing teachers' statistical thinking. In C. Batanero, G. Burrill, & C. Reading (Eds), *Teaching statistics in school mathematics- Challenges for teaching and teacher education: A joint ICMI/IASE study*, 323-333. Dordrecht, the Netherlands: Springer.
- Pierce, R., & Chick, H.L. (2013). Workplace statistical literacy for teachers: Interpreting box plots. *Mathematics Educational Research Journal*, 25, 189-205.
- Pournara, C., Hodgen, J., Adler, J., & Pillay, V. (2015). Can improving teachers' knowledge in mathematics lead to gains in learners' attainment in mathematics? *South African Journal of Education*, 35(3), 1-11.

- President's Education Initiative Research Project (1999). Commissioned research projects available online at <http://www.jer.org.za/publications/pei-research>.
- Rajendran, N., Nagendralingan, R., Noor S.S., Sopia, M.Y., Idris, M.R., & Lim, C.H. (2006). Teachers' pedagogical decision making qualities: Transforming teaching and learning. Laporan projek IRPA 2006. UPSI.
- Ramatlapana, K., & Makonye, J.P. (2012). From too much freedom to too much restriction: The case of teacher autonomy from National Curriculum Statement (NCS) to Curriculum and Assessment Statement (CAPS). *Africa Education Review*, 9(1), 7-25.
- Rasch, G., (1980). *Probabilistic models for some intelligence and attainment tests* Chicago: University of Chicago Press.
- Robson, C. (2002). *Real World Research (2<sup>nd</sup> ed.)*. Oxford: Blackwell.
- Rowland, T., Huckstep, P., & Thwaites, A. (2005). Elementary teachers' mathematics subject knowledge: The knowledge quartet and the case of Naomi. *Journal of Mathematics Teacher Education*, 8(3), 225-281.
- Rule, P., & John, V. (2011). *Your guide to case study research*. Pretoria. Van Schaik Publishers.
- Rumsey, D.J. (2002). Statistical Literacy as a Goal for introductory statistics courses. *Journal of Statistics Education*, 10(3), 6-13.
- Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students*. Pearson, New York.
- Schwab, J.J. (1964). The Structure of the Disciplines. meanings and significances. In G.W. Ford and L. Pugno (Eds.), *The structure of knowledge and the curriculum* (pp. 6-30). Chicago: Rand McNally.
- Sheaffer, R. (2004). Numeracy, statistics and Mathematics. *Montana*, 546(23), 1-10.
- Shepherd, D. (2013). The impact of teacher subject knowledge on learner performance in South Africa: A within pupil across subject approach. In *International Workshop on Applied Economics of Education, Cantazaro* (pp. 1-32).
- Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.
- Shulman, L.S. (1986a). Paradigms and research programs in the study of teaching: A contemporary perspective. In M.C. Wittrock (Ed.), *Handbook of research on teaching* (3<sup>rd</sup> ed., pp3-36). New York: Macmillan.
- Shulman, D. (1987). Knowledge and teaching: Foundations of new reform. *Harvard Educational Review*, 57(1), 1-21.
- Spaull, N. (2011). *A preliminary analysis of SACMEQ III South Africa. Working Papers*. Stellenbosch University, Departments of Economics.

- Taylor, N., & Taylor, S. (2013). Teacher knowledge and professional habitus. In N. Taylor, S. Van der Berg, & T Mabogoane, *What makes schools effective? Report of the National Schools Effectiveness Study* (pp. 202-232). Cape Town: Pearson Education South Africa.
- Taylor, N., Van der Berg, S., & Mabogoane, T., (2013). *What makes schools effective? Report of the National Schools Effectiveness Study*. Cape Town: Pearson.
- Thames, M.H., Sleep, L, Bass, H., & Ball, D. L. (2008). Mathematical knowledge for teaching (K-8): Empirical, theoretical, and practical foundations. Paper presented at *International Conference in Mathematics Education (ICME) II*, Monterrey, Mexico: ICME.
- Venkat, H.,n & Spaull, N. (2015). What do we know about primary teachers' mathematical content knowledge in South Africa? An analysis of SACMEQ 2007. *International Journal of Educational Development*, 41, 12-24.
- Wessels, H. (2008). Statistics in the South African school curriculum: Content, assessment and teacher training. *Proceedings of the 18<sup>th</sup> ICMI Study Conference and 2008 Round Table*. North West University, South Africa.
- Wessels, H., & Nieuwoudt, H. (2011). Teachers' professional needs in data handling and probability. *Pythagoras*, 32(1), 1-9.
- Willis, J.W. (2007). *Foundations of Qualitative Research: Interpretive and Critical Approaches*. London, Sage Publications Ltd.
- Wu, H. (2005). *Must Content Dictate Pedagogy in Mathematics Education?* Department of Mathematics, University of California Berkeley, USA.
- Yin, R.K. (2003). *Case Study Research: Design and Methods* (3<sup>rd</sup> ed). Thousand Oaks: Sage Publications.
- Zodik, I., & Zmaslavsky, O. (2008). Characteristics of teachers' choice of examples in and for the mathematics classroom. *Educational Studies in Mathematics*, 69(2), 165-182.

# APPENDIX 1: PERMISSION TO CONDUCT RESEARCH



education

Department:  
Education  
PROVINCE OF KWAZULU-NATAL

Enquiries: Phindile Duma

Tel: 033 392 1063

Ref.:24/8/1736

Mrs O Majeza  
PO Box 157  
Ixopo  
3276

Dear Mrs Majeza

## PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"EXPLORING THE PEDAGOGICAL CONTENT KNOWLEDGE OF FET MATHEMATICS TEACHERS"**, in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 25 February 2019 to 20 July 2021.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Phindile Duma at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

Harry Gwala District

Dr. EV Nzama  
Head of Department: Education  
Date: 26 February 2019

KWAZULU-NATAL DEPARTMENT OF EDUCATION

Postal Address: Private Bag X9137 • Pietermaritzburg • 3200 • Republic of South Africa

Physical Address: 247 Burger Street • Anton Lembede Building • Pietermaritzburg • 3201

Tel.: +27 33 392 1063 • Fax: +27 033 392 1203 • Email: Phindile.Duma@kzndoe.gov.za • Web: www.kzndoe.gov.za

Facebook: KZNDOE... Twitter: @OBE\_KZN... Instagram: kzn\_education... Youtube: kzndoe

*„Exploring Quality Education - Creating and Securing a Brighter Future*

# APPENDIX 2: ETHICAL CLEARANCE



10 June 2019

Mrs Drippa Majeza (218082374)  
School of Education  
Pietermaritzburg Campus

Dear Mrs Majeza,

Protocol reference number: HSS/0174/019M

Project title: Exploring the pedagogical content knowledge of FET Mathematics teachers

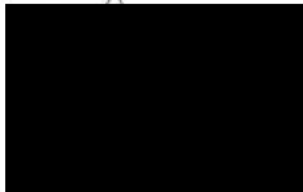
### Approval Notification – Expedited Application

In response to your application received on 01 March 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. **PLEASE NOTE:** Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 1 year from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.



Dr Rosemary Sibanda (Chair)

/ms

Co-Supervisor: Professor Carol Bertram  
cc Academic Leader Research: Dr Annette Pillay  
cc School Administrator: Ms Sheryl Jeenanain

Humanities & Social Sciences Research Ethics Committee

Dr Rosemary Sibanda (Chair)

Westville Campus, Govan Mbeki Building

Postal Address: Private Bag 31-4001, Durban 4000

Telephone: +27 (0) 31 260 3607/3650/ 557 Facsimile: +27 (0) 31 260 4036 Email: [rsibanda@ukzn.ac.za](mailto:rsibanda@ukzn.ac.za) / [anette.pillay@ukzn.ac.za](mailto:anette.pillay@ukzn.ac.za) / [sheryl.jee@ukzn.ac.za](mailto:sheryl.jee@ukzn.ac.za)

Website: [www.ukzn.ac.za](http://www.ukzn.ac.za)



Founding Campuses: Edgewood Howard College Marical R-hini Pietermaritzburg Westville

# APPENDIX 3: LETTER SEEKING PERMISSION FROM THE SCHOOL PRINCIPAL

The school principal  
Name of school

Date: 14/01/2019

Dear Sir/Madam

Re: Permission to conduct a research project in your school.

Project title: **Exploring the pedagogical content knowledge of FET Mathematics teachers.**

My name is Orippa Majeza, Master of Education student from University of Kwa-Zulu Natal, School of Education, Pietermaritzburg Campus. I am an educator from Little Flower Combined School.

I hereby request permission to conduct research in your school. The study involves an exploration into the pedagogical content knowledge of Mathematics teachers at Grade 10 level. The aim and purpose of this research is to explore the Pedagogical Content Knowledge (PCK) of selected FET mathematics teachers, to find out the reasons for the pedagogic actions of teachers in their teaching of mathematics and to develop an understanding of teacher knowledge in order to improve the ways in which teacher development programmes are designed and delivered since there has been poor achievement in mathematics for the past years. The focus of my study is on teacher knowledge.

Participation of teachers in the research will be voluntary and the results of the study will be used in improving instruction in the teaching of mathematics. Teachers will get an opportunity to reflect on their classroom practice and will try to change the ways they do things so that learners can understand better.

The study is carried under the supervision of Prof. Carol Bertram at UKZN, Pietermaritzburg. (School of Education, Humanities). If you need any clarification about the project, feel free to contact my supervisor.

**Researcher**

Orippa Majeza  
076 157 4805 [omajeza@gmail.com](mailto:omajeza@gmail.com)

**Supervisor**

Professor Carol Bertram, School of Education, UKZN, [BertramC@ukzn.ac.za](mailto:BertramC@ukzn.ac.za)

Thank you in advance hoping permission will be granted.

Yours faithfully

Orippa Majeza.....

# APPENDIX 4: LETTER TO PARTICIPANT

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE  
(HSSREC)

## APPLICATION FOR ETHICS APPROVAL

For research with human participants

Information Sheet and Consent to Participate in Research

Project title: Exploring the pedagogical content knowledge of FET Mathematics teachers.

Date: 14/01/2019

Dear Sir/Madam

My name is Orippa Majeza, Master of Education student from University of Kwa-Zulu Natal, School of Education, Pietermaritzburg Campus.

You are being invited to consider participating in a study that involves an exploration into the pedagogical content knowledge of Mathematics teachers at Grade 10 level. The aim and purpose of this research is to explore the Pedagogical Content Knowledge (PCK) of selected FET mathematics teachers, to find out the reasons for the pedagogic actions of teachers in their teaching of mathematics and to develop an understanding of teacher knowledge in order to improve the ways in which teacher development programmes are designed and delivered. The focus of my study is on teacher knowledge.

Please be advised that you are not forced to participate in this study, the decision is yours and is highly respected. However, it will be appreciated to share your views and experiences. If you decide to participate, please understand that you can withdraw at any stage of the research for any reason. There won't be any penalties or prejudice and your identity will be protected. Confidentiality will be highly observed and your identity as participants will be protected. Therefore, pseudo names will be used for you and your school to ensure the integrity and confidentiality.

The study is expected to enroll three teachers from three different schools. It will involve the following procedures, observations, stimulated video recall and interviews. I humbly ask for your permission to do video recording and audio recording. I will be asking you questions and I request that you be as open and honest as possible in your answers. I will also ask you to draw a concept map for the concepts of the lesson you are going to teach I will request also that after the lesson we view the video together so that we can discuss some behavior

and why you behaved in some particular way. The observations will take 30 minutes and the interviews 30-45 minutes. The information you provide will remain confidential and you are assured that there won't be any comebacks from the answers you give. Please also note that there won't be any remuneration for participating in this study.

Please know that there are no anticipated risks or harm to you. The purpose of the observation is not meant to assess you in any way and the outcomes of the research will not be used anywhere. The study might be beneficial to you as it will give the opportunity to reflect on classroom practice in terms of content knowledge, knowledge of student thinking and their difficulties so that you can think on how to improve in future.

If possible, I would like to come back when the study is completed to inform you of the outcome of the findings.

In the event of any problems or concerns/questions you may contact the researcher at [omajeza@gmail.com](mailto:omajeza@gmail.com) or my supervisor Prof. Carol Bertram, [BertramC@ukzn.ac.za](mailto:BertramC@ukzn.ac.za), and or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows:

**HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION**

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557- Fax: 27 31 2604609

Email: [HSSREC@ukzn.ac.za](mailto:HSSREC@ukzn.ac.za)



# APPENDIX 5: LEARNER ASSENT

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC)

## APPLICATION FOR ETHICS APPROVAL

### For research with human participants

Information Sheet and Consent for learner to Participate in Research

Project title: Exploring the pedagogical content knowledge of FET Mathematics teachers.

Date: 28/02/2019

Dear Learner

My name is Orippa Majeza, Master of Education student from University of Kwa-Zulu Natal, School of Education, Pietermaritzburg Campus.

My study focuses on the practices of your mathematics teacher, who has agreed to participate in the study.

The study involves the observation of one mathematics lesson and the video- recording of one mathematics lesson. The focus of the observation and video- recording will be on the teacher's practice and not on you. However, ethical research practices require that you are aware of the study and give your consent to participate. Please know that there are no anticipated risks or harm to you.

The data will not be made public in any way and will only be used for research purposes. The video-recording will be deleted when the study is completed.

The school and teacher's identity will not be made public.

In the event of any problems or concerns/questions you may contact the researcher at [omajeza@gmail.com](mailto:omajeza@gmail.com) or my supervisor Prof. Carol Bertram, [BertramC@ukzn.ac.za](mailto:BertramC@ukzn.ac.za), and or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details below.

-----

**LEARNER ASSENT FORM**

I (Name) ....., a learner in Grade 10 .....

have been informed about the study, “Exploring the pedagogical content knowledge of FET Mathematics teachers”, by Orippa Majeza.

I understand the purpose and procedures of the study.

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at [omajeza@gmail.com](mailto:omajeza@gmail.com) or Prof Carol Bertram at (033) 260 5349.

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000 KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557 - Fax: 27 31 2604609

Email: [HSSREC@ukzn.ac.za](mailto:HSSREC@ukzn.ac.za)

I hereby assent to be present during:

Video-recording of a mathematics lesson YES / NO

Lesson Observation of a mathematics lesson: YES / NO

Use of learner’s work YES / NO

\_\_\_\_\_  
**Signature of Learner**

\_\_\_\_\_  
**Date**

\_\_\_\_\_  
**Signature of witness**

\_\_\_\_\_  
**Date**

# APPENDIX 6: PARENT CONSENT

UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC)

APPLICATION FOR ETHICS APPROVAL

For research with human participants

Information Sheet and Consent for your Child/ ward to Participate in Research

Project title: Exploring the Pedagogical Content Knowledge of FET Mathematics teachers.

Date: 28/02/2019

Dear Sir/Madam

My name is Orippa Majeza, Master of Education student from University of Kwa-Zulu Natal, School of Education, Pietermaritzburg Campus.

My study involves an exploration into the pedagogical content knowledge of FET Mathematics teachers at Grade 10 level. Your child's/ward's mathematics teacher has agreed to participate in the study.

The study involves the observation of one mathematics lesson and the video-recording of one mathematics lesson. Your child/ward is a learner in this class, and thus I am requesting your consent.

The focus of the observation and video recording will be on the teacher's practice and not on your child /ward. However, ethical research practices require that you are aware of the study and give your consent on behalf of your child/ward. Please know that there are no anticipated risks or harm to your child/ward.

The data will not be made public in any way and will only be used for research purposes. The video recording will be deleted when the study is completed.

Confidentiality will be highly observed and the school and teacher's identity will be protected. Therefore, pseudonyms will be used for the teacher and the school to ensure the integrity and confidentiality.

In the event of any problems or concerns/questions you may contact the researcher at [omajeza@gmail.com](mailto:omajeza@gmail.com) or my supervisor Prof. Carol Bertram, [BertramC@ukzn.ac.za](mailto:BertramC@ukzn.ac.za), and or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details below.

I (Name)..... the parent/guardian of

..... (child/ward) in Grade 10 .....

have been informed about the study, “*Exploring the pedagogical content knowledge of FET Mathematics teachers*”, by Orippa Majeza.

I understand the purpose and procedures of the study.

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my child’s/ward’s participation in this study is entirely voluntary and that s/he may withdraw at any time without affecting any of the benefits that I usually am entitled to.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at [orippa@gmail.com](mailto:orippa@gmail.com) or Prof Carol Bertram at (033) 260 5349.

If I have any questions or concerns about my child’s rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus  
Govan Mbeki Building  
Private Bag X 54001  
Durban  
4000 KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557 - Fax: 27 31 2604609

Email: [HSSREC@ukzn.ac.za](mailto:HSSREC@ukzn.ac.za)

I hereby provide consent for my child to be present during:

Video-recording of a mathematics lesson YES / NO

Lesson Observation of a mathematics lesson: YES / NO

Use of learner’s work YES / NO

\_\_\_\_\_  
**Signature of Parent/Guardian**

\_\_\_\_\_  
**Date**

\_\_\_\_\_  
**Signature of Witness**

\_\_\_\_\_  
**Date**

# APPENDIX 7: STRUCTURED OBSERVATION SCHEDULE

Date: .....

School: .....

Name of teacher: .....

Grade: .....

Observer: .....

Duration of observation: .....

Topic:

.....  
.....

Objectives:

.....  
.....  
.....  
.....  
.....

Lesson introduction of  
concept:.....

.....  
.....  
.....  
.....  
.....  
.....

Presentation of content:

.....  
.....  
.....  
.....  
.....  
.....  
.....

Misconception of learners:

.....  
.....  
.....

.....  
.....  
.....

Learner difficulties:

.....  
.....  
.....  
.....  
.....

How teacher interprets and addresses misconceptions and difficulties:

.....  
.....  
.....  
.....

Teaching strategies:

.....  
.....  
.....  
.....

Activities and learner exercise books:

.....  
.....  
.....  
.....

Learner involvement:

.....  
.....  
.....  
.....

Conclusion of lesson:

.....  
.....  
.....  
.....

# APPENDIX 8: SEMI-STRUCTURED INTERVIEW SCHEDULE FOR TEACHERS

## Biographical details

Name of teacher: .....

School: .....

Grade taught: .....

Time: .....

## Interview question pre-observation

1. When did you start teaching mathematics?
2. What are your qualifications?
3. Which other grades are you teaching in mathematics besides Grade 10?
4. Did you study any statistics module especially with methodology on how to teach statistics?
5. What instructional strategies do you use when teaching statistics?
6. What is the purpose of your lesson?

## Interview questions post-observation

1. For how long have you been teaching?
2. For how long have you been teaching mathematics?
3. What are your academic qualifications?
4. What subjects did you major in?
5. What was the purpose of the lesson?
6. Do you think the purpose of your lesson was achieved?
7. Why do you think the purpose of your lesson was achieved/not achieved?
8. Why did you use the examples you did for this lesson?
9. Why did you ask these questions?
10. What are some of the misconceptions that learners often have for this topic?
11. What prior knowledge must learners have before they learn this topic?
12. What is your understanding of how this topic links to Grade 9 and Grade 11?

## APPENDIX 9: RESPONSES FROM T1, T2 AND T3 INTERVIEWS

**Table 8: Responses from teachers from T1, T2 and T3 interviews**

	Teacher 1	Teacher 2	Teacher 3
Purpose of the lesson	T1 purpose of the lesson was to draw the box and whisker plot and interpret.	T2 purpose of lesson was to reflect and revise the five number summary, represent it on a box and whisker and interpreting the box and whisker.	T3 purpose of the lesson was to draw the box and whisker diagram comment, and interpret.
Do you think purpose of the lesson was achieved?	Teacher said she thinks the purpose of the lesson was achieved.	T2 indicated that the lesson was achieved evident from the classwork, majority of the learners having been able to find the five number summary a, draw a box and whisker diagram and interpreting it.	T3 just said yes he believes purpose was achieved but he will be sure to what extent when the learners write a test.
Why did you use the resources which you used?	Teacher said she used the chalkboard to write questions and notes to copy for learners. She uses textbook for classwork and homework individual assessment.	Teacher said having 34 learners in class they all have different learning styles so he uses different methods to accommodate every learner. Teacher said he uses chalkboard for every learner to see if he is demonstrating, drawing or working out problem. He uses worksheets for assessments like classwork. He uses textbooks for learners to work individually.	Teacher said he uses the resources that are available.
How do you decide on the instructional strategies when teaching the box and whisker?	Teacher said he uses the resources that are available, for example, textbooks and chalkboard. Platinum is the available textbook at his school. However, he said these resources were 90% successful in his teaching. He also uses the ATP which is extracted from the CAPS document.	Teacher said he chooses his methods based on the different learning capabilities of learners as you can't just use explanation.	Teacher said he uses the resources that are available, for example, textbooks and chalkboard. Platinum is the available textbook at his school. However, he said these resources were 90% successful in his teaching. He also uses the ATP which is extracted from the CAPS document.

Do you vary teaching methods when teaching statistics depending with topic.	Teacher said she varies teaching methods depending with topic.	Teacher just indicated ye she varies teaching methods.	Teacher said he varies teaching methods.
Do you think your instructional strategies were effective?	Teacher said her instructional strategies were effective, that is, the class activities, class discussion, learners coming to the board to present their solutions and homework.	Teacher said his strategies were effective as many learners were able to do the work given. He also indicated that it was effective because the worksheets were taken from different examination papers so that the learners are familiar with how questions are asked in the examination format.	teacher said his strategies were effective to a certain extent according to his experience. He said score many marks in the box and whisker.
Why did you ask those questions?	Teacher kept on asking on the skewness of the box and whisker plot because she said learners have misconception in commenting on distribution.	Teacher constantly asked on the position of quartiles since learners confuse them with actual quartiles.	Teacher said he keeps on asking questions on skewness and median because there are the ones with most misconceptions. He said there is still a problem in quartiles and the median is the key concept.
What misconceptions do learners have on this topic?	Teacher indicated the learners have difficulties with identification of median. Learners have also a confusion in commenting the box and whisker. He said learners do not know whether to look at the box or whiskers.	Quartiles confuse the learners. One learner asked, "why $\frac{1}{4}$ ?", indicating they do not have thorough comprehension on fractions. On quartiles teacher also indicated that learners confuse the position of a specific quartile with the quartile itself when using formula, for example; Position of $Q_1 = \frac{n+1}{4}$ $\therefore Q_1 = ?$ He indicated that they also have misconceptions on commenting. If they see a longer tail the think they are working with many data entries. Teacher explained it was about the spread of the data.	Teacher indicated the learners have difficulties with identification of median. He said from experience he has learnt to start with less data, like 3 numbers, go to 4 until more numbers. Learners have also a confusion in commenting the box and whisker. He said learners do not know whether to look at the box or whiskers. Teacher just said he will try to explain to leraners.
Do you think your learners learnt all what you wanted them to learn in this lesson?	Teacher said she believes her leaners learnt what she wanted them to learn.	Teacher said yes the learners learnt what he wanted them to learn because they were able to draw and interpret the box and whisker.	Techers just said yes he believed learners learnt what he wanted them to learn.

What prior knowledge must learners have before they can understand the quartiles?	Teacher said the learners must have prior knowledge of fractions and measures of central tendencies from grade 9.	Teacher indicated that learners must have a prior knowledge of fractions. So in the introduction he tried to cover fractions.	Grade 9 basics of statistics like median and mode.
Did your learners master the key concepts?	Teacher said her learners masters the concepts but still need to redress the interpreting of the box and whisker which is still confusing learners.	Teacher said majority of learners mastered key concepts as they were able to answer questions.	Teacher said that he believes his learners mastered the concepts but a test assessment would give him clear picture.
What is your understanding of how this topic links to grade 9 and grade 11 work?	Teacher indicated that topic links to grade 9 fractions where they learn quarters and it continues to be tested in grade 11 and 12.	Teacher said topic links to grade 9 fractions and Grade 10 serves as a foundation for them to continue with the topic in grade 11 and same concepts will be used.	It links grade 9 median and mode and grade 11 percentiles.

# APPENDIX 10: TURNITIN

Majeza final thesis May 2020

---

ORIGINALITY REPORT

---

**14%**

SIMILARITY INDEX

**7%**

INTERNET SOURCES

**6%**

PUBLICATIONS

**12%**

STUDENT PAPERS

---

PRIMARY SOURCES

---

<b>1</b>	<b>Submitted to University of KwaZulu-Natal</b> Student Paper	<b>2%</b>
<b>2</b>	<b>Submitted to Middle East Technical University</b> Student Paper	<b>1%</b>
<b>3</b>	<b>hdl.handle.net</b> Internet Source	<b>1%</b>
<b>4</b>	<b>repository.up.ac.za</b> Internet Source	<b>1%</b>
<b>5</b>	<b>Submitted to Da Vinci Institute</b> Student Paper	<b>&lt;1%</b>
<b>6</b>	<b>Sarah Bansilal. "A Rasch analysis of a Grade 12 test written by mathematics teachers", South African Journal of Science, 2015</b> Publication	<b>&lt;1%</b>
<b>7</b>	<b>Submitted to Stockholm University</b> Student Paper	<b>&lt;1%</b>
<b>8</b>	<b>Submitted to University of Pretoria</b> Student Paper	<b>&lt;1%</b>

---