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KWAZULU-NATAL**

**INYUVESI
YAKWAZULU-NATALI**

**EXPLORING TEACHERS' INSTRUCTIONAL PRACTICES,
CONFIDENCE AND BELIEFS IN TEACHING MATHEMATICS
AND STATISTICS**

Student: Mrs ODETTE UMUGIRANEZA

Student No: 209541470

Supervisor: Prof. Sarah Bansilal

Co-supervisor: Prof. Delia North

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College of Humanities

School of Education

University of KwaZulu-Natal, Pietermaritzburg

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ABSTRACT

An important contributor to the quality of teaching mathematics is the knowledge of mathematics teachers. In this study, I explore mathematics teachers' instructional practices, their confidence and beliefs about the teaching of mathematics and statistics concepts. The reason for focusing on mathematics as well as statistics teaching is that in several schools' mathematics teachers also teach statistics (because statistics is a part of mathematics). This inspired me to undertake a study in order to investigate teachers' instructional practices in teaching both mathematics and statistics among learners from grade 4 and upwards in KwaZulu-Natal (KZN) schools. The use of KZN as a research location provides an advantage of identifying issues of mathematics teachers' practices in developing countries.

The study was conducted with 75 mathematics teachers from KwaZulu-Natal (KZN) in South Africa who agreed to participate in the study while they were enrolled in an in-service course designed to improve their understanding of statistics. The teachers were invited to participate by filling in a detailed questionnaire, which was adopted from the study of Beswick, Callingham and Watson (2012) which was conducted with teachers from Australia. The detailed questionnaire consisted of open ended, Likert scale as well as yes-no responses.

The instrument surveyed the teachers about various aspects of their teaching practices such as the formulation of lesson objectives, the use of the different approaches to introduce mathematics and statistics topics, the use of various teaching and assessments strategies to teach different topics as well as their descriptions about learners' possible understanding or misunderstanding of the topics. The study also elicited from the teachers their reflections about how they would improve mathematics and statistics teaching and learning. In addition, the study examined the teachers' beliefs about using mathematics and statistics in everyday life as well as in the classroom, and their confidence in relation to teaching the various mathematics and statistics topics. In addition, the study explored how teachers integrate technology in teaching and learning maths/stats topics. Furthermore, their content knowledge was put under the spotlight through the examination of their solutions to mathematical tasks.

The findings revealed that 65.3% of the participants managed to set appropriate lesson objectives. Moreover, these teachers reported that they mostly use practical examples, real life approaches and explicit instruction when teaching the topics. It was also reported by most teachers that they tend to focus on a single approach when they introduce a concept in the classroom. Furthermore, less than half the teachers reported that their learners showed an understanding of mathematics and statistics concepts. For the methods and assessments, teachers generally use a single method and more than one type of assessment. I also found that teachers mostly focus on teacher-led instructional methods and formal assessments. Furthermore, the findings revealed that teachers' demographic factors such as teaching experience, gender and participation in professional development courses are associated with the choice of a variety of teaching and assessments methods ($p\text{-value}<0.05$).

For the use of curriculum, the findings revealed that 19% of teachers had no idea about how they would integrate topics across the curriculum in teaching and learning. With respect to the teachers' reflections about improving teaching and learning mathematics and statistics, teachers said that developing learners' interest in learning these conceptions, developing grouping and learner-centred approaches for teaching, applying investigation, practical and real life examples would contribute to improvements. Furthermore, the findings suggest that teachers should use the curriculum in the teaching process and upgrade their studies by doing postgraduate courses in education as the factors that would influence them to make a continuous improvement in the teaching process. The findings showed that participating in professional development courses is a factor that motivate teachers to use curriculum ($p\text{-value}<0.05$).

For their content knowledge about solving specific tasks, the findings revealed that teachers demonstrated more understanding in finding the correct answer for the problem of using percentage than for fraction and pie chart. However, they struggled to provide justifications for their answers. This indicated a lack of specialised content knowledge, which refers to ability to give the detailed mathematics explanations to teach the given task and weigh up and analyse unconventional solution methods of their students. Teaching experience becomes an important factor to help teachers develop their content knowledge and solve mathematical tasks appropriately ($p\text{-value}<0.05$).

In terms of their confidence in teaching various topics, the finding revealed that teachers were confident in teaching fractions, decimals, percentages, histograms and pie charts, patterns and measurements; however their confidence was lower with respect to teaching aspects requiring connections between mathematics and statistics to other learning areas. In relation to their beliefs, teachers reported a positive view towards the need to be mathematically and statistically literate in everyday life, as well in their teaching practices in general. With regards to the use of technology in teaching mathematics and statistics, the findings indicated that almost all the teachers reported that they never use computers in mathematics and statistics discourse. Although the teachers reported that they do not use computers in teaching and learning, about 80% of the participants conveyed a positive view that using technology improves learners' understanding of mathematics and statistics.

The findings further indicate that the teachers' propensity to use technology in instructional practice is associated with demographic factors of age, experience and gender (p -value <0.05). The study suggests that teachers should attend more professional development programmes which would improve existing teaching strategies.

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To my brothers and sister for their motivation, this is my opportunity to thank them for their encouragement and patience.

DECLARATIONS

I, Odette Umugiraneza, declare that:

- i. The research reported in this dissertation, except where otherwise indicated, is my own work.
- ii. This dissertation has not been submitted previously for any degree or examination at any university or other higher education institution.
- iii. This dissertation does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

Student: Mrs Odette Umugiraneza

Supervisor: Prof. Sarah Bansilal

Co-Supervisor: Prof Delia North

DEDICACE

To Almighty God for his love and mercy.

To my husband Dr Faustin H., for supporting me financially and morally.

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My role in each paper and presentation is indicated. The * indicates corresponding author.

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ABBREVIATIONS

AIMSSEC	African Institute for Mathematical Sciences Schools Enrichment Centre
DoBE	Department of Basic Education
CAPS	Curriculum and Assessment Policy Statements
NCS	National Curriculum Statement
SKT	Statistical Knowledge for teaching
SPSS	Statistical Package for the Social Sciences
SAS	Statistical Analysis System
MKT	Mathematical Knowledge for Teaching
KZN	KwaZulu-Natal
PCK	Pedagogical Content Knowledge
TPCK	Technological pedagogical content knowledge
TIMSS	Trends in International Mathematics and Science Study
CK	Content Knowledge
HCK	Horizon Content Knowledge
KCC	Knowledge of Content and Curriculum
KCS	Knowledge of Content and Students
KCT	Knowledge of Content and Teaching
SA	South Africa
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SCK	Specialized Content Knowledge
TIMSS	Trends in International Mathematics and Science Study
UKZN	University of KwaZulu-Natal

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CHAPTER I. INTRODUCTION

I.1 Background

There is much concern about the poor mathematics achievement in South Africa. Both regional and international evaluations of the performance of South African children indicate that they do struggle to reason arithmetically (DoBE, 2012). For instance, in 2011, The Trends in International Mathematics and Science Study (TIMSS) revealed that South African learners have the lowest performance among all 21 middle-income countries that participated in the survey. Again in 2015, the TIMSS reported that three in five South African learners (61%) do not demonstrate the minimum capabilities in basic mathematical knowledge required at the Grade 5 level. In addition, studies emphasize that students had inadequate statistical knowledge before the introduction of C2005 (North & Zewotir, 2006). Previous studies highlighted several factors which contribute to learners' low performance in mathematics and statistics.

On the one hand, it was reported that the problem of poverty, incomes and structures of schools, low teachers' requirement, and poorer education principles in schools are the main causes of the lack of success in mathematics (Siyepu, 2013). On the other hand, this failure in mathematics is attributed to the teachers' lack of conceptual knowledge, and poor understanding of the subject matter (Feza-Piyose, 2012). Motshekga (2016) points out the mathematics teachers' insufficient knowledge of curriculum use. Moreover, North and Zewotir (2006) highlight the lack of teachers' content knowledge in teaching statistics ideas.

The Department of Education has introduced many interventions over the past few decades to try and make improvements. Teachers have been inundated with numerous curriculum revisions since the introduction of democracy in South Africa. The new government tried to bring in a system of education that was different in spirit and vision than the previous apartheid inspired education system. Initially in 1998, Curriculum 2005 (C2005) was based on the philosophy of Outcomes Based Education (OBE). Four years later, C2005 was reviewed and the NCS were introduced in 2006 as the third curriculum. In 2012, the new Curriculum and Assessment Policy Statements (CAPS) were introduced to schools (DoBE, 2011b). The impact of these

numerous curriculum revisions on mathematics particularly, has meant that some topics that were included have been removed while topics that did not previously appear in curriculum were also introduced.

With the introduction of C2005 the South African Education Department followed the global trend of including topics that had more real life applications, and the statistics offering was expanded. This was a positive move which was strengthened even further with the next round of curriculum revisions which is the Curriculum and Assessment Policy Statements (CAPS). However, the increased focus on statistics had ramifications for the classroom teaching, because most teachers had not received training in the teaching of statistics during their initial teacher training programmes (North & Zewotir, 2006). Because of their limited or no training in statistics, many South African mathematics teachers have low confidence and competence in teaching statistical literacy (North & Zewotir, 2006). Some authors noted that statistics, related to data handling and probability, are still taught traditionally (Wessels & Nieuwoudt, 2010). Studies often point to teachers' content and pedagogic content knowledge as areas that need attention (Bansilal, Mkhwanazi, & Brijlall, 2014; Feza-Piyose, 2012; Venkat & Spaul, 2015). In the last two decades many professional development programmes have been introduced in a bid to help teachers improve their mathematics knowledge for teaching. To improve mathematics teachers' level of teaching, different projects for professional training courses related to mathematics teaching have been carried out in the country (Ono & Ferreira, 2010), for example AIMSSEC which was created in 2003 to build new skills, new hopes, and new horizons for mathematics in South African schools. North and her colleagues designed a series of workshops that they ran for mathematics teachers in KZN. The maths4stats project was developed in 2007 by Stats SA (National Statistics Office) to improve statistical teaching in South Africa schools around the country. The KZN maths4stats lecture series builds on the earlier national maths4stats lecture series, but is quite different in having a fixed annual profile with a set number of hours, lesson plans, etc. The biggest difference is that the lessons are all presented on UKZN campus by experienced academic statisticians (North & Scheiber, 2008; North & Zewotir, 2006). This study is set within the stats for maths programme with the purpose of exploring the participant's mathematics knowledge for teaching.

In this study, I make a distinction between statistics and mathematics, although in school, statistics forms part of the core mathematics curriculum. Because of the limited focus paid to statistics prior to C2005, it is important to try and identify patterns and trends about the teachers' thinking about statistics particularly. Hence there is often a distinction between mathematics and statistics in this study. There is an increasing demand for learners to understand statistical ideas in a way that allows them to apply it in real life (Garfield, 1995). This author argued that it is imperative to learn some rudiments of statistics in order to have ability of understanding and evaluating information in the world. According to him "learning statistics means learning to communicate using the statistical language, solving statistical problems, drawing conclusions, and supporting conclusions by explaining the reasoning behind them" (p.26). For teachers to teach statistics in a manner that is aligned to Garfield's ideas, requires teachers to have mathematical skills as well statistical thinking and reasoning (Burgess, 2009). Furthermore, scholars suggest integration of technology in relation to improving mathematical (Moore, 2012) and statistical (Lesser & Groth, 2008) learning and understanding.

I.2 Study rationale

In this study I set out to explore the knowledge and practices of mathematics and statistics teachers in the teaching of particular concepts. The study focuses on various aspects of their teaching practices (including the formulation of lesson objectives, the ways in which they introduce mathematics and statistics topics, their teaching and assessment strategies and the use of technology in their teaching); their descriptions about their learners' conceptions and misconceptions; their beliefs about using mathematics and statistics in everyday life as well as in the classroom; and their confidence in relation to teaching the various mathematics and statistics topics. Their content knowledge is explored through the examination of their solutions to mathematical tasks.

I.3 Objectives of the study

- 1) To explore how KZN mathematics teachers describe:
 1. Their understanding of lesson objectives;
 2. Their introductory approach to particular topics;
 3. Their perceptions of their learners' responses to their teaching;
 4. The different approaches used in their teaching and assessing of mathematics and statistics topics in KwaZulu-Natal schools;
 5. Their confidence and beliefs in relation to teaching mathematics and statistics topics and factors which influence teachers' confidence;
 6. How they work across the curriculum in teaching mathematics and statistics;
 7. Their ability in using technology in teaching mathematics and statistics;

- 2) To explore teachers' proportional reasoning in solving the proportional tasks.

- 3) Teachers' reflections about how the teaching and learning of mathematics and statistics could be improved and the associated demographic factors.

- 4) To explore associations between teachers' demographic factors and:
 - a) Their teaching methods and assessments strategies;
 - b) Their confidence and beliefs;
 - c) Their used of technology;
 - d) Their use of curriculum;
 - e) Their proportional reasoning;
 - f) The strategies they suggested about they would about improving the teaching and learning;

I.4 Key research questions

1. How do KZN mathematics teachers describe aspects of their teaching practices in teaching mathematics and statistics topics?

- What do the teachers' written responses reveal about their understanding of lesson objectives?
- How do teachers describe their introductory approach to particular topics?
- What are their perceptions of their learners' responses to their teaching?
- What are the different approaches used by teachers in their teaching and assessing of mathematics and statistics topics in KwaZulu-Natal schools?
- At what level do mathematics teachers express their confidence and beliefs in teaching mathematics and statistics concepts?
- In what ways do mathematics teachers work across the curriculum in teaching mathematics and statistics to enhance students understanding?
- What are some demographic factors that are associated with their confidence and beliefs how are these associated?
- To what extent do the teachers integrate technology in their teaching of mathematics and statistics?

2. What do the teachers' responses to statistics and mathematics tasks reveal about their knowledge for teaching mathematics and statistics?

- What are some misconceptions held by the teachers themselves with respect to concepts encountered in these tasks?
- What are some demographic factors that are associated with teachers' proportional reasoning?
Is there any relationship between teachers' proportional reasoning and their confidence and beliefs?

3. What are the teachers' suggestions about how the teaching and learning of mathematics and statistics could be improved?

4. Is there any relationship between teachers' demographic factors and their

- a) Their teaching methods and assessments strategies
- b) Their confidence and beliefs
- c) Their used of technology
- d) Their use of curriculum
- e) Their proportional reasoning
- f) The strategies they suggested about they would about improving the teaching and learning

I.4 Theoretical framework

This study follows the theories developed by previous researchers. These include the frameworks of (1) Shulman (1987), (2) Ball, Thames and Phelps . (2008), (3) Burgess (2008, 2009) and (4) Mishra and Koehler (2006), Koehler and Mishra (2009) and Beswick et al. (2012).

Shulman (1987) suggests that every teacher should have the access to seven categories of teachers' knowledge such as content knowledge, knowledge of the curriculum, knowledge of learners and their characteristics, pedagogical content knowledge, general pedagogical knowledge, knowledge of education's contexts and knowledge of education's ends and purposes. Shulman puts a strong focus on pedagogical content knowledge (PCK) as it encompasses content and pedagogy. Shulman (1987, pp. 14-15) describes different steps of pedagogy emphasizing that teaching must start with comprehension of the subject matter. Teachers must have an understanding of what they are supposed to teach, in different forms. He adds that teachers must understand how the ideas relate each other in the same subjects. The next step of pedagogy is "transformation" which involves preparation, illustration of the new ideas in the procedures of analogies, as well as choosing the best methods to teach the subject matter. He calls the third step "instruction" where teachers use a variety of methods to teach the concept. In this step teachers use clear explanation approaches, classroom discussion, cooperative learning, grouping, or other methods which make the subject matter understood.

The fourth step is "evaluation" where teachers examine students' understanding and misunderstanding by applying formal and informal tests (homework, assignments, projects, investigations, etc.). The next step is "reflection"

which consists of revising the teaching and learning that has occurred and reflects, ratifies and checks out which point must be improved for the next lesson. In this study, I used this theory to explore how teachers set learning objectives of the lesson that they hope to be achieved by the end of the course (in chapter III), and teaching methods and assessments strategies that they use to teach maths and stats concepts (chapter V). I also looked at how they integrate curriculum to enhance teaching understanding and teachers' reflections about how teaching and learning must be improved (chapter IV).

Since this study was done on mathematics teachers, using Ball et al.'s theory, I explored their levels of mathematical understanding in solving mathematical and statistical tasks. I explored their mathematical content knowledge as well as their statistical content knowledge in terms of finding the answers and justifying how they got the answers towards these tasks (see chapter VII)

The use of technology was further explored in this study since it was claimed as a tool that facilitates teaching and learning. Mishra and Koehler (2006) and Koehler and Mishra (2009) assert that the intersection of technology, pedagogy and content would enhance teaching and learning and develop students' understanding. These authors suggest teachers should know technological tools and how content can be improved by the application of specific technologies. In this study, technology use was explored by examining how teachers use technology in their instructional practices (see chapter VII).

In addition, confidence and beliefs are necessary for a mathematics teacher who teaches both mathematics and statistics (see chapter VI). Beswick, Callingham, and Watson (2012) state that confidence and beliefs are part of teachers' knowledge and that confidence is manifested by the enjoyment of mathematics. I agree that teachers need confidence to stimulate and the ability to motivate their learners to love the concepts. Also, Grossman, Wilson, and Shulman (1989) and Umugiraneza, Bansilal and North (2016) emphasised that any discussion on teachers' knowledge should go together with beliefs. In this study, teachers' confidence and beliefs were explored by examining their level of confidence in teaching mathematics and statistics topics and beliefs about how mathematics and statistics are taught in the classroom as well as their beliefs about how mathematical numerate and literate they are in everyday situations.

I.5 Outline of the study

This study follows the form of a thesis by publication. Accordingly each chapter comprises a full paper which has been published, in press or under review.

It is composed of eleven chapters. In chapter I, I present a general introduction of this study where I discuss the background of the study, study rationale, objectives of the study, main research questions and theoretical framework of the study. In chapter II, I present the detailed methodology used where I discuss the research paradigm of the study, instrument used, sampling method, data collection approach and the trustworthiness of the study. In chapters III to VIII, I explore general teaching practices, where chapter III focuses on teachers' planning of lesson objectives, the approaches they are more likely to use to introduce the specific mathematics /statistics topic in the classroom, and how learners provide feedback to these topics. Chapter IV examines teaching and assessments strategies that teachers mostly use to teach mathematics and statistics topics. Binary logistic regression was also used to identify the factors which may influence teachers to use multiple teaching and assessments methods.

In chapter V, I examine how teachers work across the curriculum to contribute to a good teaching and learning, i.e. How they integrate curriculum in teaching and learning mathematics and statistics. In this chapter, binary logistic regression was used to identify the factors that are associated with the use of the curriculum.

In chapter VI, I explore how teachers rated their confidence about how they teach various mathematical and statistical topics, their beliefs about using mathematics and statistics in everyday life and beliefs about the nature and teaching of mathematics and statistics in the classroom. I also examine the factors associated to teachers' confidence.

Chapter VII, I examine teachers' knowledge of technology in teaching and learning mathematics and statistics, the factors which can be associated with the use of technology as well as the relationship between teachers' use of technology and their confidence and beliefs.

In chapter VIII, I investigate mathematics teachers' level of proportional reasoning towards mathematical and statistical tasks. I further use binary logistic

regression to identify the factors associated with their proportional reasoning. Furthermore, I use chi-square test of statistics to examine the relationship between teachers' proportional reasoning and their confidence and beliefs.

Chapter IX deals with teachers' reflections regarding how they would go about improving teaching and learning mathematics and statistics topics. In this chapter, the use of binary logistic regression helps to explore whether there exist some factors that influence teachers to have multiple views about how they would improve teaching and learning.

In chapter X, I present the general discussion where I report the findings for every research question discussed in I.4. The final chapter (chapter XI) deals with the general conclusions where I present the overall picture of the study, its implications, limitations of the study, reflections on further studies and critical reflections on the theoretical framework.

CHAPTER II. METHODOLOGY

This chapter consists of five sections. The first part discusses the research paradigm used in this study. The second part discusses the sampling method used to select the participants. The third part states the methods used to collect the data and the characteristics of items. The fourth part discusses the coding scheme used to code information and the approach used to analyse the data whereas the fifth part involves discussion about trustworthiness of the research.

2.1 Paradigm

Paradigm is defined as a way of looking at the world (Mertens, 2014). It is composed of certain philosophical assumptions which guide and direct thinking and actions. According to Guba and Lincoln (1994), paradigms describe the “basic belief systems based on ontological, epistemological, and methodological assumptions”. It therefore consists of finding out the answer to the three fundamental questions namely: “what is the form and the nature of reality and, therefore, what can be known about it (ontology)” and then “what could be the nature of the relationship between the knower or the would-be knower and what can be known (epistemology)” without forgetting “how the inquirer (would-be knower) goes about finding out whatever he or she believes can be known (methodology)” (Guba & Lincoln, 1994). A research paradigm represents a particular worldview that defines, for the researchers who hold this view for instance, what is acceptable to research and how this should be done (Bertram & Christiansen, 2013). In addition, it determines the formulation of the research problem and how it is handled methodologically (Torsten & Postlethwaite, 1994; Cronje, 2014).

The ontology informs the methodology about the nature of the reality (Tuli, 2011). Ontological assumptions are concerned with what constitutes reality, in other words “what is”. In doing research, researchers are advised to take a position regarding their perceptions of how things really are and how things really work (Scotland, 2012). Briefly, ontology refers to the study of the nature of reality (Broom & Willis, 2007). Epistemological assumptions are concerned with how knowledge can be created, acquired and communicated, in other words what it means to know (Scotland, 2012). As discussed by Guba and Lincoln (1994), epistemology focuses on the following questions: “What is the relationship between the knower and what is known? How do we know what we know? What counts as knowledge?” (p.108). A

widely adopted approach to epistemology is to assume that knowledge in any field is represented by a set of propositions, together with a set of procedures for verifying them, or providing a warrant for their assertion (Ernest, 1991).

Methodology is concerned with why, what, from where, when and how data is collected and analysed (Scotland, 2012). According to Guba and Lincoln (1994) research methodology asks how the inquirer can go about finding out whatever they believe can be known? Methodology is a research strategy that translates ontological and epistemological principles into guidelines that show how research is to be conducted, and principles, procedures, and practices that govern research. Research methodologies in social science are related in the sense that they are all means of soliciting information about human nature from human participants (Tuli, 2011). This author argues that, in qualitative research, this methodology enables the participants to make meanings of their own realities and come to appreciate their own construction of knowledge through practice. Tuli adds that qualitative research methodology often relies on personal contact over some period of time between the researcher and the group being studied. Tuli further describes qualitative methods as the methods that are particularly related to understanding the “*how*” and “*why*” questions (Ulin, Robinson, & Tolley, 2012). The methods tend to be not manipulative, modest, and with no monitoring (Antwi & Hamza, 2015). They are further known as approaches that rely on personal contact over some period of time between the researcher and the group being studied (Thomas, 2010). According to Guba and Lincoln (1994), four paradigms are highlighted in scientific inquiry. These include positivism, post-positivism, critical theory, and constructivism. In the positivist paradigm, reality is out there in the world, but is independent of the investigator and it is absolutely necessary and discovered through scientific and conventional methods (Sayyed & Abdullah, 2013). Within the positivist paradigm, researchers believe that there is an external reality and there are patterns and a sense of order in the world that we can discover. They believe that world exists “out there” and thus the relationships between things can be measured. Evidence is collected through observations or experiments. The goal of research is to develop “laws” and “general principles” which govern phenomena, thereby allowing the prediction of future events. It is assumed in this paradigm that researchers aim to make claims which can be backed up by evidence. If the evidence confirms the claims they are considered proven. At the ontological level, positivists assume that the reality is objectively given and is measurable using

properties which are independent of the researcher and his or her instruments; in other words, knowledge is objective and quantifiable (Antwi & Hamza, 2015). Positivism's ontology also assumes that the reality is external to the researcher and represented by objects in space, and that objects have meaning independently of any consciousness of them (Mack, 2010).

Epistemologically, positivists assume dualism and objectivism. In other words, the investigator and the investigated "object" are assumed to be independent entities, and the investigator is capable of studying the object without influencing it or being influenced by it (Guba & Lincoln, 1994). At the methodological level, the answer is that of experimental and manipulative methods. Questions and/or hypotheses are stated in propositional form and subjected to empirical tests to verify them. In their research methods, positivists believe they have access to a "fixed, unchanging and absolute reality" (Kirby, 2013). The second paradigm is named "post-positivism". A post-positivist researcher aims to describe, control and predict how the natural and social world works. The difference is that post-positivists reject the positivist claim that the world can be known completely. Post-positivist researchers believe that humans can not only approximate the truth, or get "close enough". This means that they do not base their knowledge on facts as much as on hypotheses about the world. Rather than try to prove hypothesis, as the positivists would do, a post-positivist tries to falsify or disprove a hypothesis (Bertram & Christiansen, 2013). Martens (2005) adds that post-positivist research deals with quantitative approaches of data collection and analysis.

Ontologically, post-positivist researchers assume that the reality is best described through a critical realist perspective (Guba & Lincoln, 1994). Thus, it can be said that the reality is there but is imperfectly understood (Kirby, 2013). At the epistemological level, postpositivists assume that objectivity is possible. Special emphasis is placed on external guardians of objectivity such as critical traditions (do the findings fit with pre-existing knowledge?) and critical community (such as editors, referees, and professional peers) (Guba & Lincoln, 1994). At the methodological level, the adaptation is modified experimental and manipulative methods.

According to Bertram and Christiansen (2013), post-positivist researchers generally work in large-scale studies that they consider more likely to produce generalizable facts. They may make use of the experimental methods which use a pre-test and a post-test in order to establish the impact of a particular intervention. The

findings must be generalizable, which means that the findings need to be applicable beyond the sample of study.

Methodology in post-positivism is acknowledged as triangulation methods that allows the use of quantitative and qualitative methods (p.110). The most commonly used data collections methods in this paradigm involve experiments, quasi-experiments, tests and scales (Mackenzie & Knipe, 2006). The third and fourth paradigms are constructivism and critical theory.

On the one hand, constructivists assume the reality is relativistic (multiple local and specific 'constructed' realities) (Guba & Lincoln, 1994). Realities are apprehendable in the form of multiple, imperceptible mental constructions, socially and experientially based, local and specific in nature (although elements are often shared among many individuals and even across cultures), and dependent for their form and content on the individual persons or competing paradigms in qualitative research groups holding the constructions (Guba & Lincoln, 1994; Mack, 2010)

On the other hand, critical theory; through it the expected reality is assumed to be historical realism. It is also presumed in critical inquiry that the reality is changing over time and, therefore, it is often not supported by existing regimes (Guba & Lincoln, 1994). The reader is referred to (Guba & Lincoln, 1994) for a treatment of these paradigms.

Based on the above literature and the structure of the research problems, given that this study is a survey which used both mixed methods in data collection and analysis, and given that various codes were applied in this study, it seems that the study has aspects of post-positivist paradigm. Bertram and Christiansen (2013) articulate that "surveys are often used within the post-positivist paradigm" (p.50).

Ontologically, like positivists, post-positivists believe that a reality exists, though they hold that it can be known only imperfectly and probabilistically. As explained by Guba & Lincoln (1994), it assumes that the nature of the reality to be found is the object of the study which exists outside and independent of our minds. Thus, the reality can never be perceived in total accuracy (Phakiti, 2015). This position is called critical realism (Guba & Lincoln, 1994). This means that no single research instrument or experiment is perfect, but the reality to be found is closer to the truth. This ontology was named critical realism because of the posture of proponents that claims about reality must be subjected to the widest possible critical examination to facilitate apprehending reality as closely as possible (but never perfectly) (Guba & Lincoln,

1994). As a critical realist, it has been significant to interpret and critically examine the findings in order to make them apprehendable (understood) (p.110).

Onwuegbuzie, Johnson, and Collins (2009) clarify this, emphasising that today's practising quantitative researchers would regard themselves as post-positivists. Holding that there is an independent reality to be studied, but that all observation is inherently fallible, we can only approximate the truth, never explaining it perfectly or completely. Hence, given the fallibility of observations, post-positivist research lays emphasis on inferential statistics with its emphasis on producing probabilities that observed findings are precise (not certainties).

The information was gathered using closed and open-ended questions which are potential for post-positivists (Lauster & Srivastava, 2014). Using qualitative method, teachers reported their teaching practices regarding how they would go about improving the quality of teaching and learning mathematics and statistics; how a particular mathematics and statistics topic is taught in classroom: how it is introduced; methods and assessments they use as well as how they would work across the curriculum in order to assess a good teaching and learning. Using open-ended questionnaires, they were also required to report their expected responses from their students (how they would answer the mathematics and statistics tasks): and express the strategies they would apply to teach these tasks in the classroom. In the same line, teachers expressed on a scale their confidence regarding how well they teach most of mathematical and statistical topics, and beliefs about "being numerate" and "being literate" in everyday lives and beliefs about teaching mathematics and statistics topics in the classroom. Therefore, all information was reported by the participants on the questionnaires they had been given, without the influence of the researcher; I was only placed as external guardian playing a role of coding, analysing interpreting and judging the data. Teachers' confidence and beliefs, professional learning and technology information were collected using quantitative methods in which teachers expressed their confidence and beliefs using Likert scales and were analysed using statistical programs.

According to the literature, this method may fit with the post-positivist paradigm. However, the findings which emerged from this study do not support the assumption of generalizability which characterises post-positivist paradigm, given that the participants have been selected purposively by the DoE to attend a professional course. Therefore, the present contextual findings help develop knowledge and

understanding for the participants who were attending one particular maths4stats course only. On the other hand, the findings can be transferable to other contexts, since post-positivism uses qualitative approach which was used in this study.

2.2 Sampling

The sample was composed of approximately 75 in-service mathematics teachers from KwaZulu-Natal. These teachers were selected purposively by DoE to attend the five-week session of the KZN math4stats lecture series in 2015 on UKZN campuses.

Purposive sampling means that the researcher makes specific choices about which people to include in the sample (Palys, 2008; Teddlie & Yu, 2007). The researcher targets a specific group, knowing that the group does not represent the population, it simply represents itself. (Tongco, 2007) articulates that “choosing purposive sampling is a fundamental to the quality of the data gathered; thus, reliability and competence of the informant must be ensured” (p.147). Purposive sampling is often done with convenience sampling which means choosing a sample which is easy for the researcher to reach (Morse, 2010). Researchers rely on their experience, ingenuity or previous research findings to purposely obtain units of analysis in such a manner that the sample they obtain may be regarded as being representative of the relevant population. The adequacy of this kind of sampling for quantitative studies depends on the judgment of the researcher, and is therefore sometimes even called *judgment sampling*. In purposive sampling the researcher must first think critically about parameters and then choose the sample case accordingly.

Maths4stats course was established in 2009, following the hosting of the International Statistics Institute conference (ISI2009) in Durban by Prof. Delia North. The lecture series was defined to be a joint project between the provincial office of StatsSA (national statistics of South Africa), UKZN and the KZN provincial office of the DoE (North, Zewotir, & Gal, 2014). The math4stats project was launched in 2007 and is one of Statistics South Africa’s (Stats SA, the National Statistics Office) legacy projects aimed at encouraging the development of mathematics education through improving the teaching of statistics at school level. Maths4stats aims to generate a specialized body of educators with a passion for mathematics, and to inspire the love

of and awareness in mathematics and statistics in educators and learners (North, Scheiber, & Ottaviani, 2010).

The KZN maths4stats lecture series was a spin-off of the original national maths4stats lecture series, is aimed at KZN teachers only, and is a special project between the KZN provincial offices of the DoE, Stats SA and UKZN. It represents an effort to restore numeracy and statistical literacy in the worst performing schools in the province. It is an annual program that provides training in the teaching of statistics to around 136 teachers per year on campuses of UKZN. The teachers were selected by the DoE (KZN), according to the schools in most need of assistance in training of mathematics. The KZN maths4stats workshop series was designed to give each of the three partners a distinctive role, with overall planning aiming to make the programme as cost-effective as possible, so as to be sustainable in a country with economic constraints. A key feature of the programme is that each of the lessons is given by experienced academic statisticians, fully employed in the School of Mathematics, Statistics and Computer Science at UKZN. Further details of the programme are contained in North, Zewotir, et al.(2014).

2.3 Data collection

Data collection was done using questionnaires. According to de Leew (2005), self-administered questionnaires are useful methods for collecting simple information that is relatively easy for respondents to provide. The use of self-administered forms is more economical and practical for collecting data from large numbers of respondents, particularly when dispersed over wide geographic areas. Self-administered questionnaires can be delivered to participants in a group setting such as a clinic, research facility, or workplace, or individually through the postal service or the Internet.

These are implemented in two ways. The first way is self-administered questionnaires completed in the presence of research staff, where the researcher interacts with respondents and may provide clarifications regarding the study or study materials if needed, and some degree of monitoring of the environment in which data are collected. The second way is self-administered questionnaires distributed and returned by mail, which can be rapidly and widely disseminated to a large number of

potential respondents to collect simple information on a wide variety of topics. They may be particularly useful for collecting sensitive information that the respondents may be reluctant to provide to an interviewer or record in the presence of investigator.

In this study, questionnaires containing items regarding teachers' knowledge, practices and beliefs were distributed to KZN mathematics teachers. The questionnaire was divided into four parts: Likert scale questions (Archambault & Crippen, 2009; Beswick et al., 2012), open-ended questions and closed-ended questions (Lauster & Srivastava, 2014) as well as multiple choice questions (Wilkinson & Birmingham, 2003). Likert scales questions asked teachers to rate on a scale their level of agreement and open-ended questions required teachers to write down their ideas regarding their teaching practices (to suggest plans and strategies they would use about improving teaching and learning mathematics and statistics, teaching and assessments methods used in the classroom, and the work across the curriculum in order to contribute to a good teaching and learning mathematics and statistics). For the details, see the Appendix.

On the one hand, qualitative methods were applied in data collections, where teachers had to write down freely their suggestions related to GPK questions. Multiple choice questions measured teachers' professional knowledge about their use of curriculum documents in classroom. Furthermore, they were asked to write down their intervention on these three problems about teaching and make more clarifications in the face of a student's inappropriate answer. Closed-ended questions were related to teachers' professional knowledge and technology.

On the other hand, quantitative methods was also used where information was collected using successive numbers called Likert scales. This was applied on teachers' confidence and beliefs, professional knowledge and technology data. Moreover, demographic questions such as age, experience in teaching mathematics and experience in teaching statistics were further collected using quantitative methods. The study also used multiple choice questions to gather teachers' demographic factors and their use of curriculum documents in classroom.

All information was captured and analyzed using statistical packages. Following the work of Beswick et al. (2012), this study is a survey which used questionnaires to collect data. As discussed above, this study used a pilot test as the preliminary stage where the research instruments were trialled with people to see if the questions were understandable (Bertram & Christiansen, 2013). I chose this type

of data collection because I was expecting to use 136 teachers, which is a large number of participants, and the questionnaire was too long. Secondly, the questions were well structured and they could respond to them in my absence. I used this method in order to give my participants enough time to think about the answers and to allow them to freely respond without my influence.

2.4 Instrument: Characteristics of items and coding

The items included in this study include five parts:

2.4.1 Questions about demographic factors

Demographic questions were included in this study in order to examine their influence on teaching practice. For instance: do female teachers hold a higher level in using technology than male teachers? Do old teachers express a higher level of confidence than young teachers? Etc. Demographic information included gender, age, experience in teaching mathematics, experience in teaching statistics, level of study, field of study and school quintile in which they teach. Teachers were presented with multiple choice questions about their demographic factors and they were required to choose which group they belong to. Below is an example of the questions about demographic factors.

Participants

Table 2.1 presents a description of the participants in terms of various demographic factors. It shows that the study included 50.3% of male and 49.3% of females, 58.7% were ≤ 40 years and 41.3 were >40 years old, 46.7 have completed bachelor's degree or less and 53.3 % have completed postgraduate or above, etc.

Table 2. 1 .Participants by demographic factors and coding

Factors	Definition (codes)	Frequency (%)
Gender	Female (0)	37 (49.3)
	Male (1)	38 (50.3)
Age group	≤40 years old (0)	44 (58.7)
	>40 years old (1)	31 (41.3)
Level of education	Bachelor's degree and below (0)	35 (46.7)
	Postgraduate and above (1)	40 (53.3)
Quintile school	Q1 (0)	15 (20.0)
	Q2 (1)	28 (37.4)
	Q3 (2)	16 (21.3)
	Q4 and above (3)	16 (21.3)
Phases	GET (grade4-9) (0)	30 (40.0)
	FET (grade10-12) (1)	45 (60.0)
Teaching experience	≤10 years (0)	45 (60.0)
	>10 years (1)	30(40.0)
Attended mathematics workshop	No (0)	30 (40.0)
	Yes (1)	45 (60.0)
Met with a local group of teachers to study and discuss mathematics and statistics teaching on a regular basis	No (0)	24 (32.0)
	Yes (1)	51 (68.0)
Observed other teachers teaching mathematics/statistics as part of your professional development	No (0)	11 (14.7)
	Yes (1)	64 (85.3)
Use National Curriculum Statement (NCS) Grade R-12 in teaching mathematics and statistics	Not use it (0)	30 (40.0)
	Use it (1)	45(60.0)

2.4.2 Items about general teaching practices

The study included the items regarding teaching practices in order to explore to what extent mathematics teachers are able to specify learning objectives of the lesson, the strategies that teachers use to introduce mathematics and statistics topics in the classroom, and how learners provide feedback in terms of their understanding of mathematics concepts. Besides this, the study included the items requesting teachers to state the different approaches used by teachers in their teaching and assessing of mathematics and statistics topics. Furthermore, there were items

requesting teachers to respond how they could work across the curriculum to improve the teaching and learning of the chosen concept and whether they have used the curriculum document (NCS grade R-12) in teaching mathematics and statistics.

The questions were formulated as follows: If you were planning to teach a concept from your mathematics or statistics program, how would you go about teaching it? Choose a concept that you think is important, for example: percentage, measurement, mental computation, ratio, fractions, algebra, data types, surveys, questionnaires, populations and samples, tally table, frequency, pictograms, bar graphs, pie graph, histogram, scatterplot, grouping data, mean, median, mode, range, stem and leaf plot, random experiment, events: (certain, uncertain, impossible), frequency, probability, chance etc. Please outline how you might design and teach a unit for your chosen topic to develop an understanding with your learners.

- 1 Concept (chose one concept).....
- 2 Understanding objective(s) of the concept to be taught.....
- 3 I would introduce the concept by:.....
- 4 Teaching methods and grouping, I would include:.....
- 5 Assessment methods and strategies, I would include:.....
- 6 My learners generally respond to this concept by.....
- 7 How do you work across the curriculum in order to contribute to learners' understanding of this concept?.....

2.4.3 Items about teachers' strategies about improving maths and statistics teaching and learning

This part includes the open-ended questions requesting teachers to write down the strategies they think they would use to improve mathematics and statistics teaching and learning. The questions were formulated as follows: How would you go about improving the understanding of Mathematics and Statistics (Data Handling) amongst learners in grade 4 and up? Please state the main goals, plans and strategies that you would use and why (ex. I would improve students' interest in mathematics, because it makes them very nervous about learning it).

- 1a) To improve the teaching and learning of Mathematics, I would:.....
- b) I would do this because:.....
- 2a) To improve the teaching and learning of Statistics, I would:.....
- b) I would do this because:.....

2.3.4 Items related to teachers' confidence and beliefs

The items regarding teachers' confidence and beliefs were included in this study in order to explore how confident mathematics teachers are about teaching mathematics and statistics concepts, their beliefs about their numeracy and literacy skills in everyday life, their beliefs about the teaching and learning of mathematics and statistics and factors that can contribute most to building confidence in teaching statistics and mathematics topics.

The total items in this part are 59, with 31 items related to mathematics and 28 items related to statistics (Table 2. 2 to Table 2. 4). Teachers were required to rate their perceived level of confidence in their ability to facilitate understanding in mathematics and statistics topics. Rating was done on a scale ranging from 1 (very low) to 5 (very high) for all 17 mathematics and statistics topics (Table 2. 2). Teachers were further required to rate 21 statements concerning the beliefs related to the teaching of mathematics and statistics in the classroom (Table 2. 3). Participants had to rate each of the 21 statements individually, by reacting to each statement on a scale ranging from 1 (strongly disagree) to 5 (strongly agree) (See Section 5 in Appendix).

Finally, to get feedback related to 14 statements concerning the beliefs of their own mathematical and statistical skills in everyday life (Table 2. 4). This rating followed reactions to statements where participants had to give a rating of 1 (disagree) to 3 (agree) (See Section 6 in Appendix).

The data were coded such that the more positive the response, the higher the score. Consequently, where items were stated in the negative, codes were reversed so that a consistently high score would indicate a higher level of desired outcome (Beswick et al., 2012; Beswick, Watson, & Brown, 2006). In each case the responses were thus scored 1-5, with 1 indicating the lowest level of confidence or the level of agreement considered by the researchers to be most negative, and 5 indicating the highest level of confidence (Table 2. 2), or level of agreement by the teachers to be most positive, except teachers' beliefs about teaching mathematics and statistics in the classroom (Table 2. 3) and beliefs about using mathematics and statistics in everyday life (Table 2. 4).

Table 2. 2 Teachers' confidence items

Fractions
Decimals
Percentages
Ratios and proportions
Measurement (Length, area, weight, volume, temperature, speed and time)
Presenting mathematics in an expository style (detailed explanation)
Pattern and algebra
Mental computation
Connecting mathematics to other key learning areas
Critical debate on mathematics and statistics in the media (newspapers, TV, internet...)
Pie graphs and histograms
Simple probabilities understanding and calculations
Range and variations
Inference and prediction
Connecting statistics to other key learning areas
Ideas of Sampling and data collection
Using statistics out of the class room situation

Table 2.3 Items regarding teachers' beliefs about teaching mathematics and statistics

Mathematics is just computations

I would feel uncomfortable if a child suggested a solution to a mathematics problem that I hadn't thought of previously

Teachers of mathematics should be fascinated with how learners think and be intrigued (interested) by alternative ideas

Telling learners the answer is an efficient way of facilitating their mathematics learning

Allowing a child to struggle with mathematics problems, even a little tension, can be necessary for learning to occur

Mathematical content is best presented in an expository style: demonstrating, explaining and describing concepts and skills

It is important that mathematics content is presented in the correct sequence

Ignoring the mathematics ideas that children generate themselves can seriously limit their learning

Effective mathematics teachers enjoy learning and doing mathematics themselves.

It is difficult to teach mathematics without a text book

Mathematics teaching should assist learners to develop an attitude of inquiry

Mathematics in high school is best taught in mixed groups of abilities, at least until grade 9

Often the mathematics work I do in the classroom is not relevant to the students' everyday lives

I use technology to assess mathematics learning (computers, calculators)

Teachers of mathematics should be knowledgeable of the way children think and be intrigued (interested) by alternative ideas

Statistics is just computations

I would feel uncomfortable if a child suggested a solution to a statistics problem that I hadn't thought of previously

Effective mathematics teachers enjoy learning and doing statistics themselves

It is difficult to teach statistics without a text book

Statistics teaching should assist learners to develop an attitude of inquiry (asking questions, being curious about solutions)

Often the statistics work I do in the classroom is not relevant to the students' everyday lives

Teachers of statistics should be knowledgeable about the way children think and be intrigued (interested) by alternative ideas

Statistics teaching should assist learners to develop a positive attitude to problem solving

Statistical literacy, thinking and reasoning are the main goals in statistical teaching and learning

Statistical material is best presented in an expository style: demonstrating, explaining and describing concepts and skills

It is difficult to teach statistics both conceptually and procedurally

Using technology helps increasing learners' learning and understanding statistics

Table 2. 4. Items about teachers' beliefs about using mathematics and statistics in everyday life

<p>I need to be mathematical numerate to be an intelligent consumer</p> <p>I am confident that I could work out how many tiles I would need to tile my bathroom</p> <p>I often perform mental calculations in my head (without a calculator)</p> <p>I believe numeracy is becoming increasingly important in our society</p> <p>I believe numbers and how to work with them is as essential for everyone as reading and writing are</p> <p>I believe knowledge of data types, surveys, population, samples, frequency, plots, grouping data, mean, median, mode, random experiment, probability, etc.</p> <p>I have difficulty in identifying mathematics structures (forms) in everyday situations</p> <p>Proportional reasoning is needed to understand claims made in media (newspapers, TV, internet, magazines, radio)</p> <p>I have difficulty in understanding statistical facts in everyday situations</p> <p>Given the price per square metre, I could estimate how much it would cost to carpet the lounge</p> <p>Mathematics/statistics is not always communicated well in newspapers and in the media</p> <p>I often use mathematics/statistics to make decisions and choices in everyday life</p> <p>I can easily extract information from tables, plans and graphs</p> <p>Statistical literacy, thinking and reasoning is an extremely important skill to develop in everyday life</p>

2.4.5 Items related to proportional reasoning

This part is intended to examine mathematics teachers' levels of proportional reasoning in terms of solving proportional tasks and different forms of misconceptions that teachers display when solving these tasks. Also to explore whether there appear some demographic factors which may influence teachers to have appropriate proportional reasoning. And finally, to examine whether there appears any connection between proportional reasoning and other aspects of teachers' knowledge such as beliefs and confidence. Teachers were encouraged to respond using closed and open-ended questions their proposed responses to four proportional tasks, two concerning the use of fractions (Beswick, 2008a) and other two tasks involving the use of percentages (Beswick, 2008b).

This part of study implemented in KwaZulu-Natal four proportional tasks (Beswick, 2008a, 2008b) carried out in Australia. Beswick (2008a) explored students'

understanding in solving proportions tasks while Beswick (2008b) examined teachers' PCK in solving percent tasks (tasks three and four). In this study, these tasks were investigated in a different context, to examine teachers' proportional reasoning. The responses were coded hierarchically according to their degree of appropriateness such that the higher level of code corresponds to the correct answer (Beswick, 2008a, 2008b; Beswick et al., 2012). The details of the teachers' answers are reported in chapter VIII.

Proportional tasks

Task1. *Mary and John both receive pocket money. Mary spends $\frac{1}{4}$ of hers and John spends $\frac{1}{2}$ of his.*

A. *Is it possible for Mary to have spent more than John?*

B. *Why do you think this? Explain your reasoning*

Task 2. *Consider the following problem that learners were asked in a survey about chance and data: is from a survey about smoking and lung disease among 250 people.*

Table 2. 5. Smoking and lung disease

	<i>Lung</i>		
	<i>disease</i>	<i>No lung disease</i>	<i>Total</i>
<i>Smoking</i>	90	60	150
<i>No smoking</i>	60	40	100
<i>Total</i>	150	100	250

A. *Using this information, do you think that for this sample of people, lung disease is affected by smoking?*

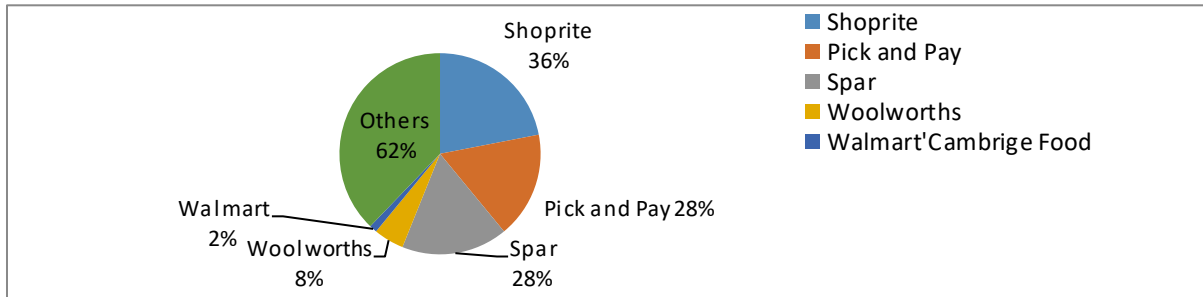
B. *Explain your reasoning.*

Task 3. **A.** *What is 90% of 40?*

B. *Explain your reasoning*

Task 4. Teachers' knowledge about pie chart

National wide retail grocery market shares (demonstration, not factual)



A. Explain the meaning of this pie chart.

B. Is there anything unusual about it?

2.4.5 Items related to the use of technology

The study included the items related to the use of technology in order to investigate the degree to which mathematics teachers incorporate technology into their teaching practices, to what extent teachers are positive about using technology in the teaching of mathematics and whether there appears any relationship between demographic factors and the use of technology in instructional practices.

I first examined the level to which teachers have access to technology (computers, calculators and internet and different instructions technology). Participants completed a questionnaire which included questions regarding the implementation of technology in their instructional practice. They were asked about their access to calculators, computers and the internet and the extent to which these were used for teaching mathematics in their classrooms. Teachers were also required to respond to statements on a four-point Likert item scale with categories '1=never; 2=rarely, 3=sometimes; 4=often' to indicate how often they integrated technology in teaching mathematics and statistics.

Table 2. 6. Using technology for instructional practice

Drill (exercise) and practice
emonstrate statistics principles
Collect data using sensors or probes (collecting data using software)
Retrieve or exchange data
Solve and compute statistical problems
Take a test or quiz

Further questions about using technology include “To what extent are the learners in your mathematics class permitted to use calculators during mathematic lessons?”

(Tick one box in each row)

Table 2. 7. Using calculators, computers and internet

Unrestricted use	Yes.....	No.....
If yes, do you use calculators to teach statistics? Yes.....	No.....	
Are computers available at your schools? Yes.....	No.....	
If Yes, would use them for teaching mathematics and statistics in class	No.....	
Do any of the computers learners use / have access to the internet? Yes ...	No.....	
If yes, do you use the internet for instructional /educational purposes? Yes.....	No.....	

2.5 Coding

Mixed method was also respected in coding where, coding was done qualitatively and quantitatively.

2.5.1 Qualitative codes

Teachers’ responses emerged from open-ended questions, were coded qualitatively in order to examine the types of strategies reported by teachers in terms of using curriculum, how they set learning objectives they expect to be achieved by the end of the course, how they introduce a topic in the classroom, the teaching and assessments they use, how their learners understand mathematics and statistics and how they would go about improving teaching and learning. In this case, coding was done by grouping the answers that have similar meaning. Then, each of us coded independently.

The coding was then compared and where there were differences, consensus was reached about the final coding. We then all of us reviewed the coding and together reached consensus where differences occurred. This process was carried out with the intention of improving the reliability and validity of the coding which are essential aspects of trustworthiness in qualitative research (Golafshani, 2003, p. 604). The details of qualitative codes are reported in Chapters III, IV and IX.

2.5.2 Quantitative codes

Quantitative codes were attributed to the questions about teachers' demographic factors, confidence and beliefs, using NCS grade R-12 and technology. I also quantified the teachers' answers using quantitative coding to explore whether teachers focus on only a single or on more than one teaching and assessment method in teaching mathematics and statistics topics as well as examining if teachers suggest single or multiple strategies about improving mathematics and statistics understanding. Quantitative studies involve the process of identifying factors that influence an outcome, which in this case was the use of multiple teaching and assessment methods as well as the strategies about improving mathematics and statistics understanding. The quantification of the qualitative data into quantitative data allowed me to run statistics tests (Driscoll, Appiah-Yeboah, Salib, & Rupert, 2007; Sandelowski, Voils, & Knafl, 2009) which enabled me to make inferences from the results. Quantification allowed me to apply hierarchical coding which is based on the idea that coding will be in the form of hierarchical quality where the lowest layer of hierarchy contains the minimum information for intelligibility. This means that succeeding layers of the hierarchy add increasing quality to the scheme. Hierarchical coding was used to explore the number of teaching approaches that teachers used to introduce mathematics and statistics concepts in the classroom and the number of teaching and assessments strategies that teachers use to teach mathematics and statistics topics in the classroom, their level of proportional reasoning as well as the strategies suggested by teachers about improving mathematics and statistics teaching and learning.

2.6 Data analysis

A mixed methods approach combining both qualitative and quantitative analysis were used in this study. On the one hand, qualitative analysis was used to analyse qualitative data, whereas quantitative analysis was also used to analyse

quantitative data (e.g. to examine the relationship between teachers' practices and their demographic factors (Table 2.1).

2.5.1 Qualitative analysis

Qualitative analysis was used to analyse the responses gathered using open-ended questions. According to (Dey, 2003) "... qualitative analysis is usually concerned with how actors define situations, and explain the motives which govern their actions" (p.36). The teachers' responses to the items were analysed using a general inductive analysis. Inductive reasoning refers to methods that mostly use detailed readings of raw data to originate thoughts, themes, or a model through explanations made from the raw data by an investigator (Thomas, 2006). This approach was used to analyse teachers' responses about how they formulate learning objectives, introduce (Chapter III), teach and assess the topic in the classroom (Chapter IV); how they work across the curriculum in order to contribute to learners' understanding of mathematics and statistics concepts (Chapter V), provide the answers towards four proportional tasks (Chapter VIII) and how they would go about improving the teaching and learning mathematics and statistics (Chapter IX).

2.5.2 Quantitative analysis

Quantitative methods involve measurements and the statistical or mathematical computations, or numerical analysis of data collected through censuses, questionnaires, and surveys (Babbie, 1989). Quantitative analysis was used to analyse the level of teachers' confidence and beliefs, their level of using technology and their level of proportional reasoning. It was further used to explore whether teachers focus on single or on more than one teaching and assessment method in teaching mathematics and statistics topics, and whether they reported a single or multiple strategies for improving the teaching and learning of mathematics and statistics. It was further used to examine how many teachers who use National Curriculum Statement Grade R-12. This process was carried out with the intention of improving the reliability and validity of the coding which are essential aspects of trustworthiness in qualitative analysis. Quantitative analysis were also used to examine teachers' level of confidence and beliefs. It was also used to explore teachers' level about using technology in teaching and learning mathematics and statistics. In order to gather teacher's confidence and their beliefs as well as their use of technology, Likert scale (Likert, 1932) was used. Likert scale approach is appropriate for "providing a quantitative measure of a character or personality trait" (Boone & Boone, 2012).

Analysis was made using IBM Statistical Package for the Social Sciences (SPSS), version 23 (George & Mallery, 2016). This package was used to identify the important factors which may influence teachers' ability to use the curriculum and teachers' multiple suggestions about improving teaching and learning. It was also used to explore the teachers' level of confidence and beliefs towards mathematics and statistics and the associated factors and their relationship with proportional reasoning and technology. Proportional reasoning was analysed by categorising teachers' answers according to their degree of appropriateness. Incorrect answers and partial answers were classified into "inappropriate reasoning" whereas correct answers were classified into "appropriate reasoning".

Moreover, I used Statistical Analysis System (SAS) to explore the factors which may influence teachers to use multiple teaching and assessment strategies (Chapter IV). SAS is a popular set of software tools which allows researchers to access,

manage, present, and analyse data. SAS programme is a sequence of steps that are submitted to SAS for execution. Each step in the programme performs a specific task. Only two kinds of steps are known to make up SAS programmes: DATA steps and PROC steps. A SAS programme can contain a DATA step, a PROC step, or any combination of DATA steps and PROC steps. The number and kind of steps depend on what tasks the researcher needs to perform (Whitlock & Square, 2006). Both SAS and SPSS helped to explore the impact of demographic factors to the strategies that teachers use to teach and assess mathematics understanding (Chapter IV) and their suggestions about improving teaching and learning mathematics and statistics' understanding (Chapter V).

2.6 Statistical testing and modelling

In order to assess the relationship between teachers' demographic factors (Table 2.1) and their teaching practices, the following statistics models and tests were used.

2.6.1 Logistic regression

Logistic regression is a predictive analysis which is mostly used to describe data and to explain the connection between one dependent variable and one or more nominal, ordinal, interval or ratio-level independent variables (Sperandei, 2014). Logistic regression analysis helps to analyse the dataset in which there are one or more independent variables that determine an outcome (Chan, 2005; Peng, Lee, & Ingersoll, 2002). The outcome is measured with a dichotomous variable or more than two outcomes. Binary logistic regression is used when the researcher has situations in which the observed outcome for a dependent variable can have only two possible types, "0" and "1" (which may represent, for example, inappropriate answer/ appropriate answer; failed/ passed). This model was accordingly used to determine whether there were any demographic factors which seemed to influence teachers' proportional reasoning, the use of curriculum, teaching and assessment use and their suggestions about improving teaching and learning.

2.6.2 *Chi-square test*

Chi-square test of independence, reported in this study, is known as a general test designed to evaluate when the difference between observed frequencies and the expected frequencies under a set of theoretical assumptions is statistically significant (Michael, 2001). Chi-square is known as a non-parametric test (distribution free) and is used to explore the relationship between two or categorical variables (Rana & Singhal, 2015). Chi-square also explores the relationship between more than two nominal variables (McDonald, 2009). This test is a standard statistical procedure to test whether there is evidence of a statistically significant relationship between two categorical variables, as opposed to the two categorical variables operating independently. This test was accordingly used to determine whether there is a statistically significant relationship between teachers' use of curriculum and teachers' confidence in teaching a variety of mathematics and statistics. Chi-square test was also used to determine whether there is a statistically significant relationship between teachers' use of technology (using technology in class or consulting the internet for educational instructions) and teachers' confidence (including beliefs). Effectively then I was exploring whether using internet or technology in the class room for educational instructions, influences the level of confidence in. and positive beliefs about, teaching in teaching mathematics and statistics. This test was further used to determine whether there is a statistically significant relationship between teachers' proportional reasoning and their confidence in teaching a variety of mathematics and statistics topics and beliefs about their

2.6.3 *Comparison of means*

Comparison of means (a standard test used to compare differences between means of two or more groups) was used to explore whether there appears a statistically significant relationship between teachers' demographic and their ability to use the different instructional practices. It was used to examine the magnitude of the difference between two groups in terms of using technology. Effect size (ES), reported in the output of the comparison of means, is a name given to a family of indices that measure the magnitude of a treatment. It is used to calculate the mean difference between two groups. Hence, it was used to examine the magnitude of the difference between two groups in terms of using technology. As most of the effect size are ranged less than 0.3, this indicates that the difference between groups of demographic factors is small in terms of using technology in teaching practice. Mean plots are used to see

if the mean varies between different groups of the data. It was used to explore the factors which may influence teachers to integrate technology in their teaching practice.

2.6.4 Non-parametric test

Non-parametric tests are commonly known to be more applicable than classical parametric techniques for Likert-scaled data. It may be used when the outcome variable (ordinal, interval or continuous) is ranked from lowest to highest (Yu, 2001). Nonparametric tests are known to be “distribution-free” methods because they do not rely on any underlying mathematical distribution (Morris, 2011). This test is based on the test on the ranks of observations (i.e., ordinal data) are available. One sample non-parametric test was used to examine whether teachers ‘confidence for teaching most of mathematics and statistics topics, is the same or different from one topic to another (Table 5.1). It was also used to verify whether teachers’ beliefs in teaching and learning and their own use of mathematics and statistics in everyday life, are also the same or different (Table 5.2 and Table 5.3).

2.7 Validity and reliability

2.7.1 Validity

Given that the study used both quantitative and qualitative approaches to collect the data, it allowed me to check whether the findings are valid and reliable. Validity and reliability are statistical measures which help to evaluate the process of data collection and analysis. On the one hand, validity is used to test whether the research accurately measures what was supposed to be measured or to what extent the results are truthful (Ary, Jacobs, Sorensen, & Walker, 2013; Golafshani, 2003).

On the other hand, reliability refers to the extent to which the research can be replicated and still expect to find similar results. This is a term mostly used in experimental research. In positivism paradigm, reliability is usually assessed in terms of the stability of results generated through the application of some measurement instrument, such as a survey questionnaire (Bisman, 2010). On the other hand, “validity includes the ability to test hypotheses adequately (internal validity) and the ability to extend the results obtained to wider settings (external validity)” (p.11).

Bisman (2010) emphasizes that the inclusion of quantitative methods also adds to convergence and consensus positions established through qualitative methods, thus reinforcing reliability and replicability. Validity in post-positivist paradigm is about how close to the truth about the world the research is. A concern is objectivity: has the

research tried to avoid bias in data collection, interpretation and generalising the findings?

2.7.2 Validity and reliability in data collection

This refers to what extent the instrument and data collection methods do indeed measure the construct they are intended to measure. This study adapted the existing successful instrument developed by Beswick et al. (2012). Using their instrument, the study collected the data regarding teaching practices related to: how teachers plan objectives of the lesson, how they introduce mathematics and statistics concepts in the classroom, how learners respond to these concepts, teachers' methods and assessments they use to teach these concepts, how they work across the curriculum to assess good teaching and learning, and how they plan to improve the quality of teaching and learning mathematics and statistics.

Where the current instrument differs from their instrument, is that the current study examines the detailed various strategies that teachers use in teaching process. The current study further collected mixed data (both qualitative and quantitative) in data collection, coding and analysis in order to achieve its accuracy.

Furthermore, in order to assure the validity and reliability, a pilot test was conducted beforehand and the errors which appeared in the questionnaires were fixed. Pilot test refers to mini versions of a full-scale study, as well as the specific pre-testing of a particular research instrument such as a questionnaire (Van Teijlingen & Hundley, 2001). Before running data collection, the questionnaire was piloted with a view to testing its validity and reliability.

The objective of running the pilot study was to make sure that the instrument was feasible for the study, to examine the reliability and validity of the instrument and trustworthiness of respondents for data collection in the main study and to explore how the instrument is practicable in order to address any problems prior to the study. This test helped me to correct some misunderstandings that were included in the questionnaires. Therefore, the validity was achieved for the part of the data collection.

The reliability was also computed by calculating the rate of returned questionnaires which were distributed (i.e. 75 over 136). I found that it was a good response rate (over 50%) as the questionnaire was very long. One could not force participants to do it, just encourage them. A response rate of over 50% in a voluntary questionnaire is actually adequate (Babbie, 1973; Stoop, 2005).

2.7.3 Validity and reliability in data analysis

The notion of validity in the post-positivist paradigm is often deemed to refer to internal validity because it has to do with potential flaws within the study itself. It has to do with the extent to which it is possible to make claims from the data (Bertram & Christiansen, 2013). As discussed in the literature, in post-positivist paradigm tradition, researchers attempt to separate themselves from the research as much as possible, whereas in qualitative methods, investigators embrace their involvement and role within the research (Bertram & Christiansen, 2013). Therefore, as a post-positivist researcher, I tried to understand whether the data explained the findings (Bertram & Christiansen, 2013). Given that both quantitative and qualitative data were collected in this study, analysis was done using both qualitative (inductive reasoning) and quantitative analysis (SAS, SPSS and Excel). Thus, validity and reliability are guaranteed for the data analysis. This was also approved by researchers and educational professionals (experts), who evaluated the articles which emerged from this thesis and agreed about appropriateness of the methods undertaken and the integrity of the final conclusions.

2.8 Credibility

It is known that post-positivist paradigm used both quantitative and qualitative methods. Thus, it is imperative to discuss the validity in qualitative approach. In qualitative research, the validity is ensured using criteria such as credibility, transferability and confirmability (Guba & Lincoln, 1982).

While the credibility in quantitative research depends on instrument construction, in qualitative research the investigator plays the role of the instrument (Golafshani, 2003). Therefore credibility refers to the findings of one research being credible to the researchers or readers (Shenton, 2004). Credibility is defined as the confidence that can be placed in the truth of the research findings. A qualitative researcher establishes rigour of the inquiry by adopting the following credibility strategies: prolonged and varied field experience, time sampling, reflexivity (field journal), triangulation, member checking, peer examination, interview technique, establishing authority of researcher and structural coherence (Anney, 2014).

Credibility is defined as the confidence that can be placed in the truth of the research findings (Anney, 2014; Jeanfreau & Jack, 2010). Credibility establishes whether or not the research findings represent plausible information drawn from the participants' original data and is a correct interpretation of the participants' original views (Brink, 1993). In this study, the analysis and coding was done by me individually, then my supervisors did do control coding. The coding was then compared and where there were differences, consensus was reached about the final coding. Thus, inter-coder reliability was only accomplished for part of the coding.

2.9 Confirmability

Confirmability refers to the quality of the results produced by an inquiry regarding how well they are supported by participants (members) who are involved in the study, and by events that are independent of the inquirer. Confirmation is the process of comparing data gathered from multiple sources to explore the extent to which findings can be verified (Houghton, Casey, shaw & Murphy, 2013). Confirmability also refers to the degree to which the results of the inquiry could be confirmed or corroborated by other researchers (Davis & Buskist, 2008) . Confirmability is further "concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but are clearly derived from the data (Schwandt, 2015). Studies suggest that confirmability of qualitative inquiry is achieved through an audit trail (Anney, 2014; Jeanfreau & Jack, 2010).

The audit trail is made up of the various steps in the data analysis and data representation processes. For example the original questionnaire responses were coded according to the details of the participants. The details of the codes assigned to each participant is stored in a file separate from the data. The details from each questionnaire were transcribed into Excel files. The coding (both quantitative and qualitative) for each of the sections were recorded in the Excel file. Depending on the type of statistical test being used, these details were then imported into the necessary statistical analysis package.

Analysis was done using excel, SPSS and SAS and results have been checked by both supervisors and independent reviewers. Modelling was done using statistical models and also checked by independent researchers.

2.10 Transferability and generalisability

Transferability refers to the degree to which the findings of a study can be transferred to other situations. Although the studies employing qualitative method are not concentrated on generalization, they do concentrate on offering understanding from the researchers' view about a single situation to allow the study to be repeated (Shenton, 2004).

According to Bitsch (2005) the "researcher facilitates the transferability judgment by a potential user through 'thick description' and purposeful sampling" (p. 85). In order to promote transferability, this study used the following strategies: first, the researcher collected rich and detailed data for the problem under investigation and provided thick descriptions of the context, methods and finding of the study (Bitsch, 2005; Lincoln & Guba, 1985); and secondly, the participants were selected by DoE through purposive sampling which allows the findings to be transferable to other situations (Ary et al., 2013; Golafshani, 2003). On the other hand, it is expected in post-positivist paradigm that the findings would be generalizable which is generally called "external validity". Of course, as post-positivist, the present finding would be generalizable to the whole population. However, since the participants were selected purposively beforehand, the findings of this study cannot be generalizable to the whole population.

2.11 Ethical considerations

All ethical considerations stipulated by the University of KwaZulu-Natal were adhered to. Out of the group of 136 teachers who were approached to take part in the study, only 75 opted to participate. The participants were guaranteed anonymity and were also given the choice to withdraw from the research if they wanted to.

I also informed the participating teachers that all of the data and everything emanating from the data would be used only for research purposes and that it would not affect their jobs in any way. Permission to carry out the research was granted by UKZN with the protocol number HSS/1529/015D.

2.12 Summary

In this chapter, I discussed the research paradigm used in this study. I found that, according to the literature, post-positivist paradigm would fit the present research. As discussed, post-positivism was declared to be good for the study which uses both quantitative and qualitative (closed and open-ended questions methods. Secondly, I presented the sampling approach used, where the participants were selected purposively by the DoE to attend maths4stats courses. Thus, the participants queried in this study were those who attended that course. Thirdly, I discussed the method used to collect the data where questionnaires were used. I decided to use this method given that the questionnaire was too long, and that it is an approach where teachers are given time to think about the questions and the answers. Fourthly, I discussed the research instrument adopted using Beswick et al. (2012) and Beswick (2008)'s instrument. The former instrument was designed to investigate the nature of mathematics teachers' knowledge. It was therefore applied in this study in a different context to identify teachers' knowledge in teaching mathematics and statistics topics in KwaZulu-Natal schools. The latter instrument was used to examine the level of teachers' proportional reasoning using four proportional tasks. Finally, I discussed the validity and trustworthiness where I explained how the study sought to achieve its validity for part of the data collection, coding and analysis. The next chapter deals with teachers' preliminary approaches in teaching mathematics and statistics concepts.

CHAPTER III. INVESTIGATING TEACHERS' FORMULATIONS OF LEARNING OBJECTIVES AND INTRODUCTORY APPROACHES IN TEACHING MATHEMATICS AND STATISTICS

3.1 Introduction

The success of a lesson depends largely on the attention given by the teacher to the planning of the lesson. In this chapter, I examine teachers' descriptions of learning objectives related to mathematics concepts. I then look at the approaches they use to introduce the mathematics and statistics topics in the classroom. Apart from introducing a topic in the classroom, I also examine the connection between learning objectives, introducing, teaching and assessing a topic in the classroom. Rusznyak and Walton (2011) comment that teachers can underestimate the complexity of teaching because they see the most visible routines as the most important part of the practice. However, it is the somewhat invisible planning details made up of conceptualising and designing instruction which account for effective teaching (Rusznyak & Walton, 2011). Crucial issues that need to be addressed during the planning process are the lesson objectives, the possible introductory strategies, learning activities, resources, assessment strategies as well as time allocation.

When introducing a topic, teachers need to incorporate strategies that open up the mind of the learners to the possibilities about what they learn, its applications and its importance in real life. Some studies argue that the way teachers introduce a new topic in the classroom contributes to learners' performance (Ma & Papanastasiou, 2006). Particularly, when teaching mathematics and statistics, the use of innovative approaches can motivate learners to pay attention in class. Researchers suggest that when introducing mathematics concepts, teachers must have an understanding of both mathematics, the pedagogical skills as well as knowledge of their learners (Gardella, 2008). Researchers advise the use of learner-centred approaches (Ma & Papanastasiou, 2006), strategies such as concept maps which assist learners to use logic, organise, connect as well as synthesize facts and to make connections between

different models, (Vanides, Yin, Tomita, & Ruiz-Primo, 2005) as well as technologically inspired “computer simulation approaches” (Mills, 2002) particularly in the teaching of statistics (Tchantchane & Fortes, 2011).

In South African schools, even though the Department of Basic Education (DoBE, 2003, p. 4) recommends that teachers make an effort to stimulate learners with different learning styles and diverse learning needs, the country still faces a problem with mathematics being taught mainly in a traditional teacher dominated style in most classrooms (Siyepu, 2013). This author asserts that the poor performance by learners in mathematics in South Africa is related to poor teaching and the use of inappropriate methods for teaching mathematics. Siyepu (2013) emphasizes that teachers are still using textbooks to direct their teaching rather than focusing on learner-centred approaches which incorporate discovery methods, investigations, real life problem solving and the use of manipulative which can increase learners motivation and interest (Miller, 2009).

This study was carried out with mathematics teachers who were enrolled in a professional development course that was designed to improve their understanding of school level statistics concepts (North et al., 2010). However the research undertaken with the teachers indicates that the teachers also need support in developing their pedagogic content knowledge that could help them design more effective instructional techniques (Umugiraneza, Bansilal, & North, 2017). Research about teacher professional development consistently emphasises that professional development programmes, while focusing on improvement of content knowledge, must also pay attention to the development of teachers’ pedagogical content knowledge (PCK) (Ball, Thames, & Phelps, 2008; James, Bansilal, Webb, Goba, & Khuzwayo, 2015; Umugiraneza et al., 2017). This study was done to raise our own awareness of the realities of the teachers who attend the professional development programmes in an attempt to be “both responsible and responsive to teachers, attending to both teachers’ knowledge and to teachers’ needs” (Sztajn, 2008, p. 300). Recent concerns in South Africa have been raised specifically about the amount and quality of attention given to the planning of lessons (Magano, 2009; Mntunjani, 2016; Ramaila & Ramnarain, 2014).

Our intention was to use these mathematics teachers' descriptions about their lesson planning and teaching approaches to understand their own PCK needs. The focus of the study was on the teachers' framing of objectives as part of their planning and the possible strategies they could use to introduce particular topics. These skills constitute a small, but very important, part of a teachers' overall Pedagogic Content Knowledge (PCK). By improving my understanding of the teachers' PCK, I hoped to improve the design of the in-service programme so that it could help the teachers' improve their planning, instruction and assessment skills. I also hope that the insights gained through this study will help other education researchers learn more about teachers' perspectives of lesson preparation and instructional approaches.

3.2 Literature Review

3.2.1 Role of learning objectives

Before teachers design any teaching activity, it is useful to focus on exactly what they expect their learners to know by the end of the lesson. To do so, teachers need to specify explicit learning objectives around which the teaching process can be planned. Without learning objectives planned beforehand, the lesson may not be well focused and may be problematic for learners to identify what they are supposed to be learning. It may be argued that learners from fully prepared teachers show stronger learning gains than those who come from underprepared teachers (Jadama, 2014).

Setting objectives is the process of establishing a direction to guide learning (Pintrich & Schunk, 2002). Learning objectives are imperative to create a pedagogical interchange so that teachers and learners understand the purpose of that exchange (Bloom, 1956). Hence objectives can be made even more useful if they are communicated to learners, so that they can see more easily the connections between what they are doing in class and how these could be related to the real world (Dean, Hubbell, Pitler, & Stone, 2012). Dean adds that through communicating learning objectives, learners know their starting point in relation to the learning objectives and determine what they need to pay attention to and where they might need help from the teacher or others. Teaching becomes successful when it has been built on good planning, a clear framework and objectives for each lesson (Moon, Mayes, & Hutchinson, 2002). Learning objectives are included in what Shulman (1987) called

“transformation”, which refers to teachers’ preparation, and representation or selection of the models that they intend to use to teach the subject matter.

Bloom (1956) categorized learning objectives using a taxonomy consisting of six levels, which emphasizes what educators want learners to know in a hierarchal form, from less to more complex. These levels are: “*knowledge, comprehension, application, analysis, synthesis, and evaluation*”. Bloom also specified action verbs classified in accordance with the levels above including “*define, explain, translate, distinguish, compose, judge*” etc.” These can help teachers distinguish the different purposes of tasks. Bloom emphasizes that these verbs are intended to measure and observe the performances expected by learners.

3.2.2 Approaches to introducing, teaching and assessing mathematics topics

The way that any topic is introduced influences learners’ perceptions of it and hence can determine their attitude towards learning about it. Hence the type of strategies used can be a factor which contributes to learners’ achievement since their motivation and interest can be captured by a well planned introduction. When introducing a topic, the teacher needs to look at different or multiple approaches which motivate learners and encourage them to learn it. Gardella (2008) advises that learning mathematics begins with making links to previous concepts and use of language that is familiar to learners to allow them to internalize the concepts. Mosvold (2006) also suggests that teaching should be linked to real life. Teachers should not focus on explaining the rules and definitions when introducing a new topic in the classroom but should try to consider more interesting alternatives. Ma and Papanastasiou (2006) assert that involving different instructional methods to begin a new topic in mathematics can have a positive influence on learners’ mathematics performance. Ma’s (1999) findings revealed that instructional methods which involve practical examples or story problems related to everyday life and learning by pairs or small groups on a project also had statistically significant positive effects on learner mathematics performance in various mathematical areas. Ma adds that learner-centered cooperative learning is also more appropriate than teacher-centered lecture instruction to set the stage for learning a new topic in mathematics. Cockett and Kilgour (2015) assert that the use of techniques which enable children to break away from the traditional classroom setting and instructional style can increase the learners’ confidence in solving difficult mathematics tasks. Posing questions can be an effective

tool to stimulate learners' thinking when introducing a lesson or a concept. Questioning approaches play a crucial role in the quality of learning, given that, when asking questions, teachers enable their learners to reason and develop their level of thinking (Chin & Osborne, 2008).

In teaching mathematics, Ball et al. (2008, p. 400) articulate that teaching mathematics goes together with "presenting mathematical ideas, responding to "why" questions, finding an example to make a specific mathematical point, modifying tasks to be either easier or harder, choosing and developing useable definitions, selecting representations for particular purposes". Other authors are of the opinion that good teaching is related to delivering clear explanations pursued by sufficient opportunities for practice (Sullivan, Bourke, & Scott, 1995), and that good instruction entails moving learners from one level to another in their understanding or ability to do certain things (Shulman, 1987). Shulman (1986) argues that it is important for teachers to have a wide repertoire of examples, methods, illustrations and representations at hand, so that the content can be clearly understood.

Assessment is a crucial component of the teaching and learning interaction and needs careful thought and detailed planning for it to be used effectively. Assessment strategies that can be used could be formative (assessment for learning) or formal (assessment of learning). Informal or formative assessment strategies such as observations, discussions, questions and answers or homework can be used to find out what learners know in order to improve learning. Small tasks worked during or at the end of each lesson, oral questioning during the lesson, and providing feedback to learners are also helpful (Umugiraneza et al., 2017). Some formal strategies could include class tests, assignments, investigations, projects and examinations to check whether the outcomes have been achieved.

3.2.3 Making connections

According to Sawyer (2008) learners must become experienced in recognizing the connections between mathematics and other forms of knowledge and between mathematics and their lived experience, and become competent in applying the mathematical knowledge necessary to make best use of such connections. Maoto, Masha, and Maphutha (2016) argue that the teaching and learning of mathematics should focus on the big ideas behind the concepts, where each lesson follows from and leads consistently to the next, instead of teaching disconnected procedures

repeatedly. The authors convey the importance of making connections explicit and accessible. If learners become accustomed to a learning environment that makes it clear how ideas are connected and related, their understanding will be strengthened and their learning experiences will be more meaningful (Maoto et al., 2016). Within the classroom itself, an experienced teacher will ensure that there are connections between the various teaching tasks so that the lesson is (or set of lessons are) coherent, with all the phases contributing to achieve the planned learning objectives. Making connections is about ensuring that the teaching presented across a chapter, lesson or series of lessons is logically developed (Maboya, 2014). Planning for connections must also consider the sequencing of topics for instruction, and an awareness of the relative cognitive demands of different topics and tasks (Maboya, 2014). In this study, I also examine the connection between the way the teachers set lesson objectives, plan the introduction, identify the teaching method and specify the assessments in the classroom.

3.2.4 Planning skills of teachers

Rusznyak and Walton (2011) comment that teachers can underestimate the complexity of teaching, because they see the most visible routines as the most important part of the practice. However, it is the somewhat invisible planning details which account for effective teaching. Rusznyak and Walton (2011) emphasise the importance of lesson planning for conceptualising, designing and delivering instruction as well as for the sequencing of curriculum content.

Amit and Hoch (2017) note the importance of teachers being able to find or develop assessment tasks that fit in with their teaching objective. The authors argue that teachers should also be able to carry out the reverse task, that of identifying the teaching objective underlying particular mathematical tasks. Amit and Hoch (2017) conducted a study with 32 pre-service teachers and 34 novice teachers which focused on the participants' ability to connect between teaching objectives and mathematical tasks. It was found that many of the teachers did not clearly understand how a teaching objective should be determined and some judged the suitability of a teaching objective based on the sequencing in the syllabus. Ramaila and Ramnarain (2014) in their study conducted with 263 South African Physical Science teachers probed the teachers about the value they saw in lesson planning. Many teachers felt that they did not have

sufficient time to spend on developing written lesson plans because so much of their time was spent on doing the assessments necessitated by the curriculum. Magano (2009), in his study about the planning and enactment of natural science lessons, found that the participant teachers did not view planning in a way that allowed them to predict what they would need to do next. The teachers did not engage in daily planning but used a framework based on the departmental work schedules or curriculum training guides. Instead of adapting these guides to suit the context in which they taught, the teachers tried to use them as they were. Mogano also found that because the lesson plans were written in a standard format, and only when the teachers found the time, they were often not written out and this impacted negatively on the curriculum delivery. Certain sections were not completed or were only taught partially, because the time allocated was not managed as planned. Mogano comments that learning programmes are just an outline and are developed once for the whole year, while drawing up detailed lesson plans requires much reflection and time. Planning requires teachers to specify what they want the learners to learn, what activities will be used in the classroom and what learners will do to achieve these lesson aims. Magano (2009, p. 80) cautions that “not developing plans means not having given what you want to do in a classroom” sufficient thought. The author found in his study that because the teachers did not give much thought to planning, their classroom practice consisted of basically selecting activities from the learner guides made available by the Education Department.

Khumalo (2012), in his study with Grade 10 mathematics teachers in rural KZN, found that the teachers did not engage in written planning for individual lessons. None of the four teachers produced any evidence of substantial engagement with the content or activities beforehand, with no written plan or guide about how they were going to proceed with the lesson. The teachers' lessons were based on problems from the textbook, or from a previous examination paper. Furthermore the lessons were introduced with scarcely any motivation about what was being done and why or how it fitted in with any of the strands in mathematics (Khumalo, 2012).

3.2.5 Teachers' knowledge for teaching mathematics

In teaching mathematics, teachers need to have knowledge of mathematical reasoning, fluency with examples and terms as well as an understanding about the

nature of mathematical proficiency (Ball et al., 2008; Kilpatrick, Swafford, & Findell, 2001). This knowledge of mathematical skills or mathematical knowledge for teaching (MKT), which is unique for teaching mathematical subjects, is defined as the mathematical knowledge required to assess the continuing tasks of teaching mathematics to learners (Ball et al., 2008). The construct of MKT can be seen as a superordinate of content knowledge (CK) and pedagogical content knowledge (PCK). On the one hand, CK involves common content knowledge (CCK) which refers to the mathematical knowledge and skills used in settings other than teaching. CCK enables teachers to know the materials that they communicate, identify whether learners' answers are correct or incorrect, or whether the definitions illustrated in the textbook are accurate. The second component of CK is specialized content knowledge (SCK), which refers to the mathematical knowledge and skills unique to teaching. SCK enables teachers to identify learners' errors, size up and handle them. The third category within the subject matter knowledge is horizon content knowledge (HCK), which describes an awareness of how mathematical topics relate over the span of mathematics included in the curriculum other than teaching. On the other hand, PCK involves three subordinates, namely knowledge of content and learners (KCS) which helps teachers to be familiar with common errors as well as deciding which of several errors learners are most likely to make. Teachers must be aware of their learners' mathematical thinking in order to evaluate how they understand or come to understand mathematics. If teachers recognise learners' level of understanding, they will be able to look at the strategies to strengthen or change the way they teach.

The second knowledge component of PCK is knowledge of content and teaching (KCT), which associates knowing about teaching and knowing about mathematics. The third component of PCK is knowledge of content and curriculum (KCC), which refers to the knowledge of instructional material and programme. Ball et al. (2008) advise teachers to have an understanding of mathematics in the curriculum which plays a critical role in directing the teaching and learning processes and guides teachers about what they have to teach, how to teach it and when to teach it. Thus, PCK is a construct that describes the teachers' ability to choose, make and use mathematical representations effectively and how to justify one's mathematical ideas. Other studies support Ball et al.'s suggestion emphasizing that interpreting learners' mathematical thinking are the main features of teachers' teaching tasks in which

teachers must take suggestions about how learners' mathematical thinking should be improved (Llinares, Fernández-Verdú, & Sánchez-Matamoros García, 2016). In statistics discourse, apart from having mathematical knowledge, studies emphasize that teaching statistical concepts requires statistical thinking (Burgess, 2009; Pfannkuch & Wild, 2004).

In this study, I explore teachers' descriptions of learning objectives related to mathematics concepts. I then look at the approaches they use to introduce the mathematics and statistics topics in the classroom. Apart from introducing a topic in the classroom, the study also examines the connection between learning objectives, introducing, teaching and assessing a topic in the classroom.

3.3 Results and discussion

The results of the teachers' reflections about the teaching of particular topics are reported in three parts, corresponding to the three research questions. Firstly, I report on the lesson objectives pertaining to the teaching of particular mathematics or statistics concepts chosen by the teachers; secondly, I summarise teachers' ideas about the ways they introduce mathematics or statistics topics in the classroom. I then look at the links between the lesson objectives and the introductions, as well as the teaching and assessment approaches described by the teachers.

3.3.1 Setting up objectives of the lesson

In this study, I asked the teachers to write down some of the objectives they thought would be appropriate when teaching the topic of their choice. Teachers' responses were grouped into two categories: *inappropriate learning objectives* and *appropriate learning objectives* (see Table 3.1).

Inappropriate learning objectives (ILOs)

ILOs were characterised by objectives without a clear indication in terms of what learners were expected to know by the end of the course. These inappropriate objectives consisted of different responses which are summarised below.

No answer

I found that eight teachers did not provide learning objectives of the lesson.

Irrelevant objective

There were five teachers who gave irrelevant responses, for example one teacher wrote “*between six and seven hours per term*” which is the amount of time they would allocate to the topic and not the actual objective of lesson. Here, teachers are not referring to any teaching process.

Motivation for teaching a concept

Four teachers provided broad aims for teaching mathematics or the reasons for studying a particular topic, instead of specifying the learning objectives for teaching a topic. For example, one response with respect to the teaching of the concept of percentage was, “*Learners will acquire skills in life when calculating interest rates, inflations growth; economic trends, etc.*”. Although this answer is not a specific lesson objective, it is an important consideration because it helps the teacher recognise the real life applications of a concept, for instance where percentage is applied. However, what is missing is what the specific objectives are of teaching the topic specified in the curriculum.

Explanation of the topic or procedure

I found that 10 teachers gave explanations related to the teaching of the topic instead of giving the purpose of the lesson. Some examples of these kinds of responses include: “*It is just dealing with number but we work with variable. Alphabet letters. It's a “name” given to a particular number*”; “*Tally table is where you record the outcomes from the activity where you do in the class*”. Some were descriptions of the concept, for example, one teacher described what she thought algebra is: “*algebra is for dealing with numbers but we work with variables*”. Some teachers explained how a certain procedure is carried out, e.g. one teacher presented an unclear explanation of how to work out 90% of 40: “*write down $90/100 \times 40$ and cancel zero and multiply*”. Other statements described activities done in the class such as “*find a mode by using a dice*”. Although the teachers' descriptions were related to the teaching of the topic, they did not specify what they wanted to achieve in terms of learners' learning by the end of the lesson.

Appropriate objectives

Appropriate objectives are characterised by statements of what learners will be able to do when they have completed instruction, e.g. *“By the end of the lesson, learners should be able to use statistical summaries, scatter plots and regression, correlation to analyse and make meaningful comments.”* There were 48 (64.0%) teachers who presented clear objectives of the lesson to be taught using appropriate verbs such as “understand, use, solve, add, multiply, convert, measure, compare, represent and identify” (Bloom, 1956). Teachers’ responses are summarised in Table 3.1 below.

Table 3. 1 Setting objectives of the lesson

Codes	Description	Frequency (%)
Inappropriate objectives	No answer	8 (10.7)
	Irrelevant objective	5 (6.7)
	Motivation for teaching a concept	4 (5.3)
	Explanation of the topic or procedure	10 (13.3)
Appropriate objectives	Learning objectives with clear learning outcome	48 (64.0)
	Total	75 (100)

Arreola (1998) discusses that a learning objective should define what the learner will be able to do to describe the conditions under which the learner will perform the task as well as the evidence used to judge whether the learning was achieved. In this study, even though many teachers have tried to set appropriate learning objectives using appropriate verbs, teachers still need to see the value of indicating these conditions in which the learners will do the given activity (Arreola, 1998; Moon et al., 2002). As part of lesson planning, details of how the topic will be mediated by the teacher and how the learning will be assessed must also be considered on a routine basis. In this study the teachers were also probed about how they would introduce the topic, the teaching strategies they would opt for as well as how they would assess the learning of the concept. I now consider some of these lesson planning details given by the teachers in the sections that follow.

3.3.2 Approaches used by teachers to introduce a topic

There were 77 descriptions of how teachers introduced the topics which were organised into five categories and the frequency of responses for each is reported in Table 3.2 and in Figure 3.1. The results in Figure 3.1 distinguish between introductory strategies for mathematics and that of statistics specifically. It is of interest to note that statistics is generally taken as a small part of school mathematics and in fact is in its infancy in the South African education landscape. The latest curriculum policies for Grades 10 to 12 increased the emphasis in statistics from 2006 and the increased statistics focus was first assessed in the final grade 12 examination in 2008 (Edwards, 2010). The results from Figure 3.1 show that teachers were able to provide more suggestions about mathematics topics than they were able to do for statistics. This difference suggests that the teachers are more accustomed to working with mathematics rather than statistics topics, suggesting in turn that curriculum changes take many years before teachers get comfortable with new topics. Clearly they found it easier to discuss teaching issues related to the topics that have been in the curriculum for a long time.

The most common type of introduction was the use of Explicit Instruction (EL) to introduce a topic in the classroom. This category consisted of descriptions focused on how the teacher would explain the topic, or what the teacher would focus on during the introduction, including definitions, explanations etc. An example of such a response is "*Telling learners that % means a 100 and is represented by %*" when teaching the concept of percentage. There were 26 cases (33.8%) related to explicit instructions.

The codes "UPE" or "RL" refer to Using Practical Examples or making Real Life links. In this category, I considered responses which make reference to a practical activity or an activity derived from a real life setting, for example "*Cutting a paper into equal parts*" for the topic of fractions; or "*looking at the number of boys and girls in the class*" for the topic of percentage. There were 23 of such cases (comprising 29.9%).

The code "PQ" refers to the teacher Posing Questions, or giving learners a task to do first. Note that the category UPE/RL also included tasks or activities, but those were for activities which derived from a practical example or a real life setting. This PQ category includes all other tasks, activities or questions that the learners are asked

to do, e.g. “*what do you mean by the word median?*” for the topic “mean, median and mode”. There were 14 responses (or 18.2%) in this category.

The code “LPC” refers to Links to Previously encountered Concepts. In this category, I considered responses where the teacher links the new concept to previous concepts or topics which were covered. The teacher could form the links by asking questions about the previous concept or could form links by showing how the concepts were linked. An example of a response that fell in this category is “*I would introduce percentages using diagrams to represent fractions*” where the teacher was describing percentages.

The code “NA” means that teachers did not report any strategy about introducing a topic in the classroom.

Table 3. 2 Different approaches used to introduce the topic in the classroom

Codes	Codes	Frequency (%)
NA	No answer	14 (5.19)
EI	Explicit instruction (definition, explanations, demonstration, etc)	26 (33.77)
UPE and RL	Using practical examples and real life	23 (29.87)
PQ	Posing questions	14 (18.18)
LPC	Making links to previous work	10 (12.99)
Total		75 (100)

These results were further broken down in terms of the mathematics and statistics topics as illustrated in Figure 3.1.

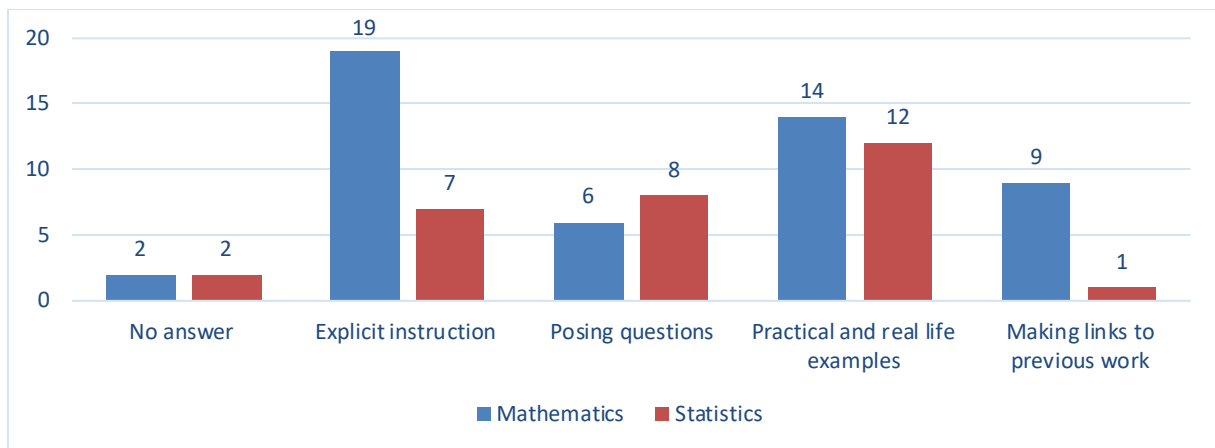


Figure 3. 1 Different approaches used by teachers to introduce a topic by subject in the classroom

The findings indicate that the most common tendency of the teachers was to revert to teacher explanations and providing definitions by way of introducing the topics to their learners. More than a third (33.8%) of the teachers' preferences was related to teacher-centred introductions. The teachers' over-reliance on teacher directed explanations may be due to a limited PCK that provides teachers' ability to shape the concept using diagrams, various representations and useful analogies so that it can be understandable to others. However, it was encouraging to note that many teachers referred to using practical and real life examples (23 or 29.87% cases), when they introduce mathematics and statistics topics in the classroom. This is a positive finding in that some teachers see value in making links between mathematics and real life, an approach that is favoured by researchers who advocate the use of real-life settings in teaching mathematics to help learners to understand the mathematical concepts (Handal & Bobis, 2003; Marshman, Clark, & Carey, 2015).

It is important for teachers to make connections concerning what learners are intended to learn, and how and why they are supposed to learn it (Dean, 2012). In line with this concern, the next stage of our study was to examine the links between the lesson objectives and the various aspects of the lesson, made up of the introduction, teaching methods and the assessment strategies.

3.3.3 Exploring connections between the lesson components

Understanding that the whole is greater than the sum of the parts, I considered it important to explore the qualitative connections between learning objectives and the introduction, teaching and assessment strategies. The detailed analysis of the teaching methods and strategies were previously reported in (Umugiraneza et al., 2017, p. 6). To explore connections between the objectives and various teaching tasks, I simply differentiated between three categories of lesson objectives: no learning objective, inappropriately phrased objectives and appropriately phrased objective. In terms of the introductory, teaching and assessment strategies, I differentiated between no or unclear strategy, and clear strategy. The result for each type of strategy appears in Table 3.3 below.

Table 3. 3 Type of teaching and assessment strategies

Codes	Description	Introductory strategy	Teaching strategy	Assessment strategy
Unclear strategy	Responses where teachers did not specify the method used	12(16.0%)	5 (6.7%)	9 (12%)
Clear strategy	Responses where teachers specified the method used	63(84.0%)	70 (93.3%)	66 (88%)

In investigating the qualitative connection between both learning objectives and that of the introductory, teaching and assessments strategies, I found that the connections varied in strength. Some teachers did not make any connection between learning objectives and teaching strategies, others made a very narrow or a narrow connection and others made clear connections. These types of connections are described below and summarized in Table 3.4.

No connection

The responses were labelled as “No Connection” if the teacher did not provide any learning objectives and also did not provide a description of the respective strategy. There were 7 cases (or 9.3%) of no connections between the objective and introducing a topic, while the associated frequency for teaching methods was 1 (or 1.3%) and that for assessment was 4 (or 4.0% cases). Note that seven out of the eight teachers who did not give a response about lesson objectives also did not specify

an introductory strategy. This may illustrate the difficulty of coming up with specific ways to introduce or motivate the importance of a topic when there are no objectives to guide the lesson planning. However, in terms of specifying assessment strategies, it seems that more teachers were unable to describe how they would assess the learners' learning than those who provided responses about objectives.

Very narrow connection

I considered responses displaying a very narrow connection in two ways. Firstly some responses did not have a clear objective, but did have a clear introductory, teaching or assessing strategy. For instance, for the topic of bar graphs, one teacher did not provide any learning objective, but she suggested introducing bar graphs by asking questions. A second type of narrow connection was when responses had a clear lesson objective but no clear strategy. An example using the topic of algebra is the objective "*learners should know the difference between variables and numbers*" with an introductory strategy "*talking with them about different things*". It is noted from Table 3.4 that teachers made a very narrow connection by making a link between lesson planning and introducing a topic (21 or 28%), teaching methods (30 or 40 %) and assessment (26 or 34.7%).

Narrow connection

This category includes the responses where teachers have mentioned appropriate learning objectives and cited clear strategies about introducing the concepts in the classroom, clear teaching and assessing strategies but the link between them was not specifically made.

For example using the topic relationships a teacher wrote the objective as "*Learners should be able to identify variables, distinguish them, understand constant relationship, constant difference*" and the introductory strategy was "*Asking the learners to define the concept and give the examples of it*". Another teacher who chose algebra reported that "*By the end of the lesson, learners should be able to solve unknown "y" value, two or more*", and the assessment strategy was "*the teacher will use exercises*". Another one who chose percentage wrote the objectives as "*By the end of the course, learners will be able to understand the percentage, and find the*

percentage of quantities of items” and the teaching strategy was described generally as *“I will use learner centred methods”*. From these examples, we note that teachers did not provide specific links between lesson objectives, introducing, teaching and assessing a topic in the classroom. From Table 3.4 we note that teachers made a narrow connection by making a link between lesson planning and introducing a topic in the classroom (3 or 4.0%), teaching strategies (29 or 38.7%) and assessments (35 or 46.7%).

Clear connection

For the responses in this category the objective was clearly phrased, the strategy was clearly described and there was a coherent and specific link between the objective and the strategy. For example with the topic frequency table, one teacher wrote the objective as *“By the end of the lesson, learners should be able to make use of data and find the tallies”* and the introduction was *“to start off by asking ages in the classroom”*. Another teacher who chose bar graph reported the objective as *“learners will develop understanding and how to conduct a research using graphs”* The introduction was described as *“I will ask learners their favourite sport and record on the board”*(introducing strategy). The findings presented in Table 3.4 show that more than half of the teachers managed to make a connection between learning objectives and introducing a topic (44 or 58.7%) and less than a quarter of them managed to make a similar connection for teaching methods (15 or 20.0 %) and for assessment strategies (11 or 14.6 %).

Table 3. 4 Connection between learning objectives and teaching assessment strategies

Codes	Description	Introduction	Teaching strategy	Assessment strategies
No connection	No clear learning objective – no clear strategy	7 (9.3%)	1 (1.3%)	3 (4.0%)
Very narrow connection	(1) Inappropriate objective-clear strategy	16 (21.3%)	26(34.7%)	20(26.7%)
	(2) Appropriately phrased objective-unclear or no strategy	5(6.7%)	4(5.3%)	6 (8.0%)
Narrow connection	Has cited a clear objective and clear strategy which are not specifically linked	3(4.0%)	29 (38.7%)	35 (46.7%)
Clear or appropriate connection	Appropriate objective - by clear strategy	44 (58.7%)	15(20.0%)	11(14.6%)
Total				75 (100%)

3.3.4 Learner responses

Knowing about learners' possible reactions and predicting what they are likely to struggle with or will find easy, is an important skill that teachers develop as they gain experience. If teachers know their learners well, they will know how they react towards mathematics and statistics topics during teaching and learning processes in the classroom. I further investigated how teachers evaluate their students' understanding of mathematics and statistics concepts. In other words, I was interested to know in what way teachers assess learners 'understanding. Table 3.5 shows the details of teachers' opinions about reactions of learners. Table 3. 5 The way learners respond to mathematics and statistics topics

Codes	Description	Frequency (%)
NA	No answer	8(10.0)
SUT	Struggle to understand the topic	7(9.0)
SU	Showing understanding and answering questions correctly	36(45.0)
AMQ	Asking more questions	8(10.0)
LGE	Learners give real examples	10(13.0)
SAP	Sharing ideas and participation	5(6.0)
SPA	Showing positive attitude and enjoying the topic	6(8.0)
Total	75 (100)	80(100)

The findings indicate that 36 (45%) teachers said that their learners respond to the concepts by answering questions that teachers ask during the teaching process. This was apparent in percentages, fractions and pie chart concepts. Others reported that learners are more likely to provide examples when they learn fractions, probabilities and percentages than other topics, and ask many more questions in algebra, pie charts, fractions and exponents than in other topics. Learners further demonstrate a positive attitude to learning ratios and algebra and enjoy learning fractions, pie charts and stems and leaf plots. However, it appeared that some learners struggle to understand percentages and ratios. Learners also struggle to calculate the mean, median, mode and range, and some just keep quiet since they lack an understanding of tally tables, mental computation and median, pie chart and bar graphs and ratios.

It was striking that only seven teachers expressed concern that their learners struggle with the content. Ten per cent (10%) of the teachers said they did not know how learners would respond. The overall finding here is that most teachers conveyed positive views about their learners' responses to their teaching. Learners' answers were also categorized using hierarchical approach in order to examine their level of understanding towards mathematics and statistics topics. This helped us to know when learners are having difficulties in understanding, when they show some understanding and when they show full understanding. For instance Table 3.6 shows that when learners are not able to convert % to fractions or fail to round up and down in decimals, this means that they show no understanding. Chin and Osborne (2008) argue that students' questions support both students in the learning process and help useful functions as a pedagogical tool for the teacher. They add that questions from students specify that they have been thinking about the knowledge they have attained and have been trying to connect with other things they know. Furthermore, when they answer the questions given to them correctly or pass the test and do well in assessments, they show a high level of understanding. The findings reported in Table 3.6, indicate that 52 % teachers reported that their learners showed both engagement and understanding, whereas 28 % showed engagement and 20% showed both non-engagement and non-understanding.

Table 3. 6 Learners' level of understanding

Scale	Definition	Description	Frequency (%)
0	Showed no engagement and understanding	Learners showed no ability of understanding the topic e.g. Failing to convert % into fractions e.g. 2% of 4 2+4=6%. They struggle saying that fractions are difficult	15 (20.0)
1	Showed engagement	Learners showed some understanding of the topics, e.g. Asking some questions in pie chart, fraction and algebra; engaging, but not taking a full participation as it is an interesting concept in learning percentage.	21 (28.0)
2	Showed both engagement and understanding	Participating getting full involved by asking and answering questions in learning exponent, for instance one teacher said that they understand more and pass the activity and achieve the outcomes in the topic of "population and sample", Asking more questions and they work on other problems other than those I give them in exponents.	39(52.0)
Total			75(100%)

Teachers' answers reported in Table 3.6, indicate that approximately a half of the students (52%) can provide both engagement and understanding to the mathematics topics. This result shows that teachers must put a great effort to motivate their learners to love the subjects. Ma and Papanastasiou (2006) suggests teachers to use different instructional methods like linking the topic to real life and using small group and other activities which motivate learners to understand mathematics.

The findings showed that only 64% reported appropriate learning objectives whereas 52% of the students understand the topics. This shows a relationship between students understanding and the way teachers set learning objectives of the lesson. This may mean that students do not show understand because the objectives were not set appropriately. Effective lesson preparation is crucial for successful teaching. Lesson planning gives teachers the opportunity to think critically about their choice of lesson objectives, the types of activities that will help to achieve these objectives, the sequence of those activities, the materials needed, the time each activity might take, and how students should be organised when carrying out the activities. When planning, teachers can reflect on the connections between one activity and the next, the relationship between the current lesson and any past or future lessons, and the correlation between learning activities and assessment practices. If

the teacher has considered these connections and can now make the connections explicit to learners, the lesson will be more meaningful to them.

3.4 Conclusion

This study was set up to investigate teachers' formulations of learning objectives and introductory approaches in teaching mathematics and statistics. I explored how teachers frame the learning objectives to be achieved by the end of their lessons. I further examined the different approaches teachers used to introduce mathematics and statistics concepts in the classroom. Furthermore, I examined how teachers evaluate learners' understanding of those concepts. The findings revealed that teachers seem to be more comfortable working with mathematics topics than statistics topics. This may be due to the fact that most of the statistics topics in the curriculum are relatively new compared to mathematics and that teachers' knowledge of statistics is still limited (North & Scheiber, 2008; North et al., 2010).

This study has shown that more than a third of the teachers did not provide a clear learning objective. Many teachers, instead of specifying particular lesson objectives, provided reasons for teaching the topic. Other teachers explained some procedures for teaching those topics instead of identifying possible objectives. Board (2016) highlights that instructional objectives specify exactly what is supposed to be learned and that they are helpful to the teacher as well as the learner. The success of any activity is largely dependent on identifying beforehand what the intention of the activity is. Since the main task of a mathematics teacher is to help learners learn mathematics, it is crucial that teachers plan beforehand what they intend to achieve at the end of a lesson. The identification of learning objectives helps teachers to focus their lessons and also helps their learners by communicating the teachers' intentions to them. Thus, objectives allow them to give learners information that can better direct their learning efforts and monitor their own progress (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010).

It is important for teachers to be creative and use various learning styles that encourage learners to think and find solutions in different dimensions. In terms of introducing those concepts, the findings indicate that teachers are using a variety of methods to introduce mathematics and statistics in the classroom. The most common

way of introducing the lesson was for the teacher to talk, explain, define or do a demonstration, that is, the use of explicit teacher instruction. This finding seems to be supported by much of the research about South African teachers where concerns are raised about the traditional teacher dominated styles of teaching (Khumalo, 2012; Maboya, 2014; Mogari, 2014; Siyepu, 2013).

Teaching that emphasises connections with or across the topics leads to a more fulfilling learning experience (Maboya, 2014; Maoto et al., 2016). In this study, the findings showed that some teachers' responses prioritised the connection between setting objectives and how a topic is introduced, taught and assessed in the classroom. The findings showed that more than half the teachers showed a clear connection between the learning objectives they cited and the methods they used to introduce the topic. However, less than half of the teachers showed a connection between learning objectives and teaching and assessing a topic in the classroom. This tells us that much effort is needed for teachers to see the importance of ensuring coherence across their lessons. The low levels of responses demonstrating connections suggest that the teachers did not check whether their plans about the various phases of the lesson made up a whole picture that connected the parts. This also indicates that the teachers may need learning opportunities which will allow them to reflect upon how these connections can be made and why such connections are crucial; hence in-service programmes need to focus on how these aspects of their mathematical knowledge for teaching (Ball et al., 2008) or statistical knowledge for teaching (Burgess, 2008, 2009) can be enhanced.

Many studies suggest teachers should hold a sufficient PCK to be able to identify learner misconceptions, design suitable teaching material and also judge the appropriateness of using examples based on the concept (Botha & Reddy, 2011; Ijeh, 2013; Shulman, 1987; Suffian, 2010).

The findings also indicate that a number of teachers did not report their ideas in terms of how learners understand the topics. This may indicate that the teachers need more experience in the area of KCS so that they can develop skills in predicting students' thinking on specific tasks. Previous researchers highlighted that there are still under qualified or unqualified mathematics teachers in South Africa (Mji & Makgato, 2006), which may be the biggest factor contributing to learners' failure in mathematics and statistics. It is therefore important that professional development

workshops focus on building up teachers' PCK and not only focuses on teaching them content. Generally, teachers need to improve their PCK and MKT.

More specifically, the study recommends that teacher development programmes focus on helping teachers improve their skills in terms of planning objectives for the concepts they teach. If a teacher cannot predict what the intention of the lesson is by specifying clear learning objectives, it is unlikely that the lesson will have focus. Poor framing of objectives may also result in teachers not finishing what is supposed to be taught in a particular period. I hope that this study brought new insights in terms of learning more about teachers' skills in lesson preparation before they engage with teaching and that they teach mathematics and statistics topics using innovative approaches. In the next chapter, I examine the details of the teaching methods and assessment strategies that teachers use in teaching mathematics and statistics.

CHAPTER IV. EXPLORING TEACHING METHODS AND ASSESSMENT STRATEGIES IN TEACHING MATHEMATICS AND STATISTICS

4.1 Introduction

In South Africa, the poor outcome in mathematics has received much attention in recent times. For example, in the Grade 12 Mathematics examination in 2015, the percentage of learners who achieved 50% and above was only 20% (DoBE, 2016b, p. 151). This means that 80% of the learners who wrote were only able to achieve a mark below 50 percent. Comments about poor results in mathematics naturally lead to questions about whether mathematics teaching is as effective as it could be. In looking at how mathematics teaching could be made more effective, a crucial issue is that of the actual methods of teaching employed by teachers to facilitate mathematics. To develop a sound understanding of mathematics and statistics with their learners, teachers need to continually update their existing teaching methods and assessments. Innovative teaching approaches can enable learners to link mathematics and statistics to real life and prepare learners to be investigators and problem solvers. Learners are expected to apply their knowledge to develop new perceptions and skills and to apply mathematical reasoning to problems in order to have the capacity to participate in today's and tomorrow's economy (Kilpatrick et al., 2001, p. 144).

Some novel teaching approaches, such as active learning methods based on investigation, discovery, cooperative learning, and simulation approaches, are more effective than concentrating on traditional approaches where teachers just apply "chalk and talk" (Serbessa, 2006, pp. 129-132). In South Africa, the Academy of Science of South Africa (Grayson, 2010) has emphasised an urgent need to increase the numbers of learners who are sufficiently proficient in mathematics and science. As an emerging resource economy, the limited numbers of mathematically proficient learners entering the workforce each year acts as a constraint to the growth of the country. Hence, the country ought to improve the learning outcomes in mathematics; to do that, mathematics teaching and assessment practices have to be improved. Barrows (1986) and Dunlosky, Rawson, Marsh, Nathan and Willingham (2013) suggest that the integration of a variety of teaching methods and assessment strategies would be the most helpful factor to improve the effectiveness of teaching

and learning practices. Furthermore, it may be the case that learners' preferred learning styles may not be their most effective learning styles. Therefore, the use of different teaching approaches has the advantage of challenging learners to think more laterally.

In this chapter, I adapt an instrument used by Beswick et al. (2012) to probe the use of teaching and assessment methods by a group of South African teachers. The instrument used by Beswick et al. (2012) aimed at measuring teachers' knowledge for middle school mathematics, by using Rasch analysis. These authors did not explore the various types of methods and assessments strategies that teachers were more likely to use, or the factors associated with the use of multiple teaching methods and assessments strategies, which are issues that I focus on in this study.

In this chapter, I explore the different approaches used by teachers in their teaching and assessing of mathematics and statistics topics in KwaZulu-Natal schools. I also examine the relationship between demographic factors of the teachers' profiles and the methods they use for teaching and assessment.

It is hoped that this study, which sheds light on the teaching practices of teachers, can help education authorities to find ways that support the use of innovative methods and assessments by teachers. Furthermore, the use of Beswick et al.'s (2012) instrument will provide greater insight into areas where teachers need more help, so that they can improve their teaching.

4.2 Literature Review

4.2.1 Teaching methods

According to Nyaumwe, Bappoo, Buzuzi, and Kasiyandima (2004), traditional approaches, which involve "teacher-centred instructional methods that do not make learners develop conceptual understanding of mathematics", have been criticised because they do not encourage problem-solving skills in learners. Instructional methods based mainly on teacher talk, do not involve much questioning, discussion or individual development of understanding. In contrast, a learner-centred teaching approach is one that supports learners in developing mathematical reasoning, while encouraging them to perceive the teacher as someone who is there to help them make sense of mathematics while creating contexts which help them develop meaning in

mathematics (Brodie, 2006; Yushau, Mji, & Wessels, 2005). However, learner-centred discourse is much harder to achieve in practice than it appears to be in policy. Chisholm and Leyendecker (2008) note that learner-centred education is one of the most pervasive ideas; yet it is very hard for them to take root in the classroom.

Such an approach requires teachers to have a variety of skills, as well as a sound knowledge of mathematics content. The use of a variety of teaching approaches and styles is recommended, because it can “encourage adapt-ability and lifelong learning in the teaching–learning process” (Vaughn & Baker, 2001). Shulman (1986), in his seminal definition of pedagogic content knowledge, articulates that “there are no single most powerful forms of representation, the teacher must have at hand a veritable armamentarium of alternative forms of representation.” Shulman’s definition focuses the need for teachers to have at their disposal a variety of ways to represent the subject matter, in order to make it meaningful to their learners.

Some common strategies in mathematics learning include direct instruction, cooperative learning and problem-based instruction. Other innovative teaching methods that can be added to teachers’ repertoires, include manipulatives, real-life application, integration of technology devices, and games (Moore, 2012). Manipulatives can be effective in creating an external and more concrete representation of the mathematical concepts being taught (White, 2012). Another teaching approach that contributes to learners’ achievement in mathematics is the integration of games in the teaching process (Moore, 2012). Using games to teach mathematics contributes to mathematical thinking and knowledge development Nisbet and Williams (2009). Ke and Grabowski (2007, p. 256) add that “[p]laying games plays important roles in a child’s psychological, social, and intellectual development.” Boaler notes that there is a gap between what researches have shown to work in teaching mathematics and what actually happens in schools. Boaler (2016) advises that teaching should draw upon rich mathematical activities, which have high intellectual demand, instead of resorting to rote learning, so that it can inculcate a positive mindset towards mathematics. Studies further argue that the connection of mathematics to real-world contexts gives teachers the opportunity of making mathematics seem more accessible and enjoyable to learners (Miller & Almon, 2009).

Researchers indicate that traditional methods, especially in teaching introductory statistics courses, are often viewed as unproductive, and result in students getting nervous about coursework because they consider statistics as a

difficult field (Smith & Martinez-Moyano, 2012). Instead, researchers advocate that small-group or cooperative learning should replace traditional methods in order to encourage more critical engagement with statistics concepts (Garfield, 1993; Roseth, Garfield, & Ben-Zvi, 2008). In recent years, there has been an increased emphasis on using real-life settings in the mathematics and statistics classroom so that learners can connect to the subject (Steen, 2001). In teaching statistics in particular, a data-driven approach can be very useful. Real data can be used to emphasise statistical principles and procedures, rather than using a traditional theoretical approach where the importance is on identifying the correct formula and performing a calculation (North, Gal, & Zewotir, 2014). Experiential learning activities allow learners to see the ways in which statistics permeate current events. Such activities draw upon the use of newspaper articles or other news sources to teach statistics concepts thereby positively influencing learners' careers and lives.

Snee (1993, p. 153) suggests incorporating a variety of learning methods so that the statistics curriculum accommodates a range of learning styles by mentioning that "using a variety of learning methods can also help some people discover new worlds that might be closed to them because the teaching methods used are not compatible with their preferred learning style." Mills (2015) adds that teachers of statistics need to search for new or alternative teaching methods to improve statistics instruction, in the hope of enhancing learning while also improving learner attitudes towards statistics. From these views, I note that the teaching of statistics could be improved using a variety of methods, given that as teachers develop their teaching styles and apply them, teachers will learn what works best in developing students' understanding of statistics.

4.2.2 Assessment strategies

Apart from using innovative teaching methods, the use of well-designed and creative assessments contributes to improvements in learning. Assessments are more than just tests and can be beneficial in mathematics; therefore, teachers are encouraged to design and use them in different ways (DoBE, 2011b). The Department of Basic Education views assessments as the process of "generating and collecting evidence of achievement, evaluating this evidence, recording the findings and using

this information to understand and thereby assist the learner's development in order to improve the process of learning and teaching" (DoBE, 2011b, p. 293).

Assessments go beyond merely evaluating what learners know and what they do not know. They generally include all activities that teachers and learners apply to acquire information that can be used diagnostically to adjust teaching and learning (Black & Wiliam, 1998). There are several types of assessments, namely diagnostic, formative, formal, informal and summative assessments (DoBE, 2011b).

The Department of Basic Education, Republic of South Africa (2011:293) encourages teachers to use formal assessments such as tests, examinations, projects, assignments and investigations in teaching and learning mathematics. These tools are applied at the end of a mathematics topic or a group of related topics in relation to measuring the product of learning, or after a period of instruction in order to judge how learning has occurred (Boston, 2002).

Diagnostic assessments can provide information about learners' understanding of related prior knowledge and skills (Ketterlin-Geller & Yovanoff, 2009). Formative assessments contribute to sustaining the teaching and learning process (DoBE, 2011b), by providing feedback of what learners can do and how the teaching needs to be adjusted to improve the learning. Formative work involves those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to adjust the teaching and learning activities undertaken. Black and Wiliam (1998) add that in order for assessment to be formative, the feedback information has to be used. Wiggins (1998) states that "providing feedback in the middle of an assessment is sometimes the only way to find out how much a student knows" in terms of the final outcome. This information can be used by the teacher to support the development of the learners' understanding. Bansilal, James, and Naidoo (2010) recommend that assessment should involve using feedback "to shape the construction of learners' understanding of mathematics." The authors also explain that scaffolding provided in the form of hints and prompts during assessment can support learners in attaining targets. Boaler (2006, pp. 41-44) provided a detailed description of an approach that led to high and equitable mathematics achievement. The mathematics classrooms across the school promoted a multi-dimensional perspective, where assessments valued many different abilities while the group work was structured so that all learners had specific roles and responsibilities.

Boaler (2016) asserts that Mathematics assessment practices should change so that they focus on improving understanding. Boaler (2016) reminds us that mistakes can present a powerful learning opportunity which teachers can take advantage of by providing feedback on the actions and how this could be improved instead of focusing on the learner characteristics.

Black, Harrison, and Lee (2004) further state that classroom dialogue, exercises and peer groups are forms of formative assessment, which are useful ways of helping students change from behaving as passive recipients of the knowledge offered, to becoming active learners who take responsibility for their own learning. Clark (2008) suggests that the use of a variety of teaching and assessment methods can stimulate learners' achievement, while pointing to the importance of specifying success criteria and learning intentions in any assessment settings. Foster (2003) articulates similarly that the integration of mixed teaching methods and assessments by involving both exercises and assignments, monitoring students' progress, advising on the progress, giving sufficient practices and giving feedback to practices in teaching mathematics and statistics, can contribute to effective learning. Based on this literature, it is noted that teaching and assessment methods play a primary role in fostering good learning and contributes to students' achievement. Therefore, when teaching, teachers have the responsibility to apply a variety of teaching and assessment methods to improve learning outcome.

4.3 Results and Discussion

The results of the study are presented in three sections, namely teaching methods, assessment methods and demographic factors. In this section, I report on the number of methods used for teaching mathematics and statistics in the class-room. Our interest is to know whether teachers apply a single method or a variety of teaching methods in the classroom, when teaching mathematics and statistics. To achieve this, I designed the codes for methods and assessments, with results as reported by teachers as presented in Table 4.1.

Table 4.1 Number of teaching and assessment methods by subject

Teaching method			
Topics	Single	More than one	Total
Mathematics	20 (43%)	27 (57%)	47 (100%)
Statistics	16 (58%)	12 (42%)	28 (100%)
Assessment strategies			
Topics	Single	More than one	Total
Mathematics	25 (53%)	21 (46%)	46 (100%)
Statistics	19(65.5%)	10 (34.5%)	29 (100%)

Table 4.1 and Figure 4.1 display the number of teaching and assessment methods reported by teachers in teaching mathematics and statistics. It can be noted that teachers were more likely to report a single method in teaching statistics topics (16 or 58%) than in mathematics topics (20 or 43%), whereas they are more likely to report more than one method in teaching mathematics (27 or 57%) than in teaching statistics topics (12 or 42%). Teachers are more likely to report a single type of assessment method in teaching statistics (19 or 65.5%) than is the case for teaching mathematics topics (25 or 53%).

Furthermore, they are more likely to report more than one type of assessment in teaching mathematics (21 or 46%) than teaching statistics topics (34.5%).

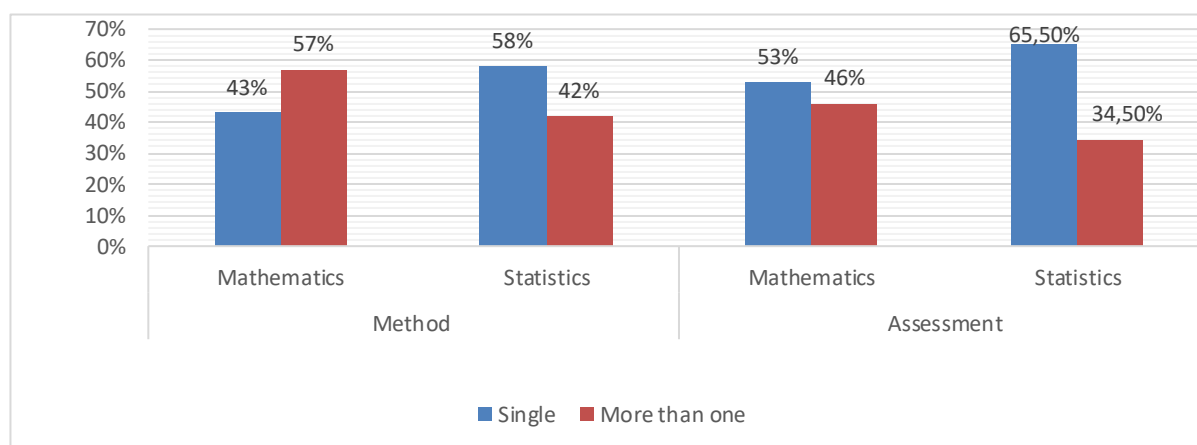


Figure 4.1 Number of teaching method and assessment by subject

This picture suggests that more than half of the teachers prefer to stick to one type of method in statistics topics, and should be encouraged to try multiple approaches. If teachers can take on a variety of methods and instruments, including systematic and

creative aspects of mathematics, then their classrooms would become more interesting for their learners (Rico, 1993, Naidoo, 2012).

This picture suggests that many of the teachers find value in using multiple and multi-faceted assessment tools in developing mathematical understanding (Dandis, 2013). However, in this study some teachers have not reported the use of multiple strategies. It is a cause for concern that so many teachers seem to be limited to one or two types of assessments. Some reasons for this could be because they find it difficult to use the assessment tools or they may not have the resources to use the tool. Moreover, as teachers were given an opportunity to choose one topic from the list, it can be noted, in Table 4.2, that 46 teachers chose to teach mathematics topics while 29 selected statistics topics. The teachers' preference for mathematics concepts may be because statistics in school is a relatively new field compared to mathematics and only assumed prominence with the implementation of Curriculum 2005 (Wessels, 2008, pp. 1-2), indicating that teachers are clearly more comfortable with teaching mathematics topics.

4.3.1 Teaching Methods

Table 4.2 reports the different teaching methods reported by teachers in teaching mathematics and statistics. It was found that teachers mostly use teacher-led explanations (show and tell, explanations, illustrations, lecturing, etc.: 24 cases or 23.1%) followed by classroom discussion (discussions, questions and answer, etc.: 17 cases or 16.4%), group work (cooperative learning, group activities, etc.: 17 cases or 16.4%) and practical instructional methods (using data from learners tests, examples they are familiar with, games, etc.).

Table 4. 2 Teachers' description of teaching methods

Themes	Codes	Description	Frequency (%)
Unclear	UM	A suggested method is not clear	5 (5%)
Teacher-led instruction	TE	Teacher explains a concept or uses the chalkboard or presents demonstration or tells learners, e.g. explanation on what percentage is	24 (23.1%)
Discussions	DI	Teacher discusses a concept or uses questions and answers to discuss a concept, e.g. 'I would use classroom discussion'	17 (16.4%)
Individual work	In	Learners do work individually, e.g. individual working	8 (7.7%)
Group work	Gr	Learners work in groups	6 (5.7%)
Learner-centred	LC	Described as learner-centred with no further details, e.g.: Use learner centred methods	3 (2.8%)
Group teaching	GT	Teachers teach together in groups, e.g. they work in group	17 (16.4%)
Assessments	Ass	Teacher uses informal assessments, assignment, e.g. Informal assessment, individual assessment	4 (3.8%)
Concrete or practical instructional material	CP	Teacher uses concrete manipulatives such as fraction walls or 3D models or diagrams as instructional material to help make a concept more understandable, e.g. the body parts like folding and stretching their arms (elbow) ask them to draw and name different angles	13 (12.5%)
Real Life examples	RL	Teacher may use data from real-life settings such as newspapers or TV as data sources, e.g. bring written data with pie chart and percentage	3 (2.8%)
Others	OTH	Investigations, projects and self-discover, e.g. investigation	4 (3.8%)
Total			104 (100%)

Figure 4.2 displays teaching methods by subject. The findings indicate that teacher-led instruction method is applied more often in teaching mathematics (25%) than statistics topics (10%) while grouping methods is applied more often in teaching statistics (18%) than mathematics topics (15%). Moutal (2016) refers to teacher-led instruction as the method in which a teacher takes an active and central role in providing information and instructions to a class. Also described in (Garrett, 2008, p. 35), "teacher-centred instruction" is not the most efficient way of facilitating content knowledge with learners, because it limits their active involvement in the learning process. A learner-centred teaching approach, on the other hand, involves supporting learners to develop mathematical reasoning skills while making meaning in mathematics and it requires teachers to have variety of skills and sound knowledge of mathematics content (Brodie, 2006; Yushau et al., 2005).

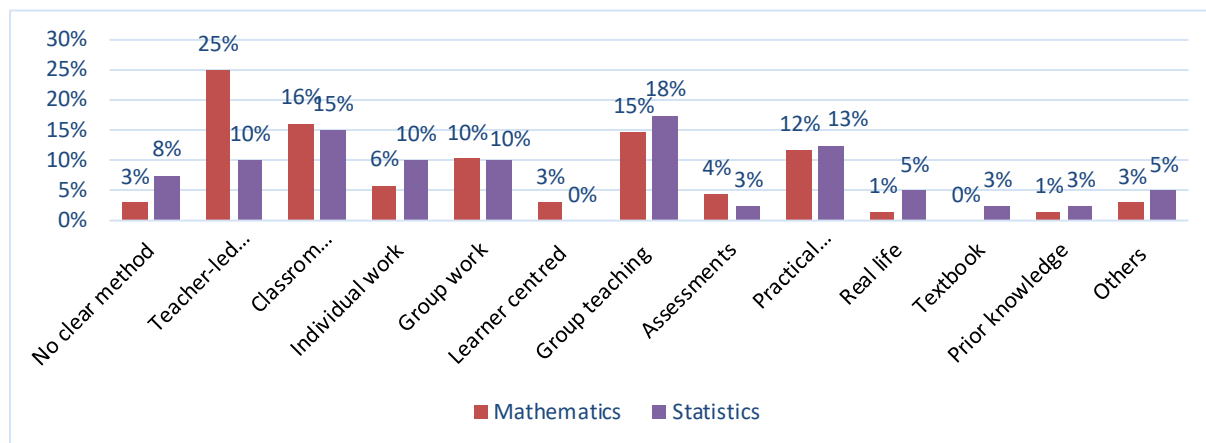


Figure 4.2 Type of teaching methods by subject

In this study, there were signs that some teachers were adopting progressive methods, albeit to a smaller extent than that of the traditional methods. It is encouraging to note... reports on the use of cooperative learning strategies such as group work and classroom discussion. Brijlall (2008) noted that the learners in his study who worked in groups were able to share valuable information with one another, an approach that gave them an advantage over those learners who worked individually.

Snee (1993, p.151) finds that motivating students to collect their own data, and conduct experiments like testing paper helicopters, would be a way of creating fun, excitement, enthusiasm and joy in learning about data in the process. Although 95% of teachers in the study (Ref. Table 4.2) reported using a well-defined teaching method to teach mathematics or statistics in the classroom, the remaining 5% showed a weakness in describing the methods they use in the classroom. One teacher described the procedure of converting fraction to percentage instead of giving the method to teach this concept, e.g. in cases where they convert fractions into percentages such as when the learners got 20 out of 30 marks, they convert to percentages.

4.3.3 Assessment Strategies

Table 4.3 represents the distribution of different forms of assessments implemented by teachers in assessing mathematics and statistics. In this study, I also found that most teachers use formal assessment methods (39 cases or 30.1%).

Table 4. 3 Coding for assessment methods

Themes	Codes	Descriptions	Frequency (%)
Unclear	UA	A suggested assessment is not clear	9 (7%)
Informal assessments	IA	Informal assessment is a daily monitoring of learners' progress. This is done through observations, discussions, practical demonstrations, e.g. class tests, class work, questions and answers, group activities to check whether they have understood	30 (23%)
Formal assessments	TA	Formal assessment tasks are marked and formally recorded by the teacher for promotion purposes, e.g. tests, assignments, investigations, projects and examinations)	39 (30.1%)
Formative, diagnostic and baseline	DF	It involves finding out what learners know in order to improve learning, e.g. small tasks works during or at the end of each lesson, oral questioning during the lesson but providing feedback to learners	35 (26.9%)
Examples of skills that are assessed	Ex	Specific skills or strategies that are to be assessed, e.g. drawing a tally table	17 (13%)
Total			130 (100%)

Moreover, Figure 4.3 displays the type of assessment strategy by subject. I note that teachers were more likely to apply formal and formative assessments methods in teaching mathematics (33%) than statistics (23%) topics while examples of skills appeared mostly in statistics topics (31%). Besides, informal assessments were also more apparent in teaching mathematics (18%) than statistics topics (11%).

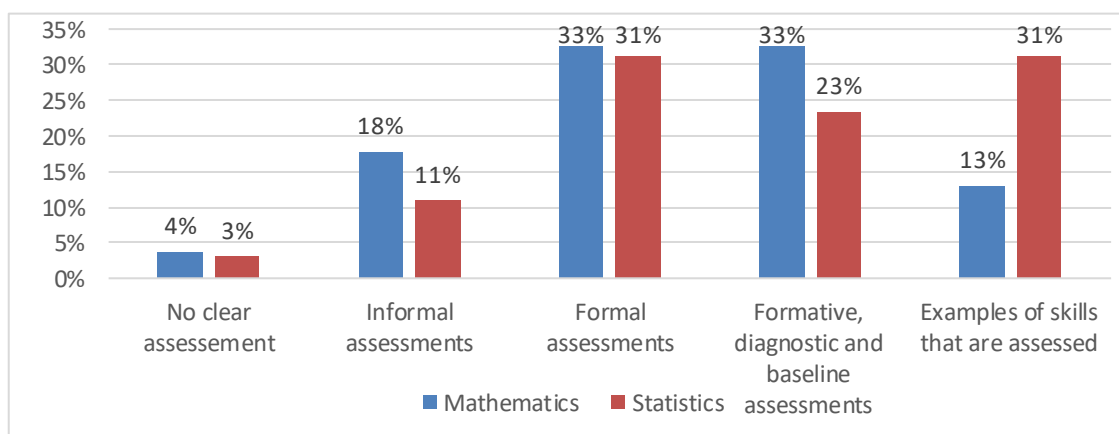


Figure 4.3 Assessments methods by subject

These results can be seen in terms of the guideline given by the Department of Basic Education, namely that all formal assessment tasks are subject to self-control for the purpose of quality assurance (DBE, 2011b). The second-highest assessment method that was cited was Formative assessment (35 cases or 26.9%). Teachers mentioned that they also use informal, class and homework as assessments. Many teachers, instead of stating the strategies they used, provided examples of the skills or knowledge that they assessed. They cited reasoning, listening, and practical examples. The examples provided suggest that informal assessment methods play a role in these teachers' practices, but that they may need more help. Du Plessis, Conley, and Du Plessis (2007) point out that the choice of assessment strategies is subject to and depends on the teacher's professional judgement, suggesting that teachers need advice and training in widening their repertoire of assessment strategies.

The DBE, Republic of South Africa (2014, p.23) has identified "the need to support teachers as well as subject advisors in the development of quality projects, assignments" as well as other assessment strategies. The findings indicate that around 93% of teachers (Ref. Table 4.3) cited a relevant type of assessment they use in the classroom. However, 7% did not report appropriate assessment methods, for instance one teacher, who chose fraction reported that "all learners in my class in order my lesson to be successful, I would give them more work". This finding indicates that this teacher is just reporting his/her belief about teaching and learning instead of reporting a type of assessment he/she uses in the classroom.

Other inappropriate examples that were given by the teachers included: the procedure for drawing a pie chart; drawing, measuring and naming angles, sorting and classifying angles, and constructing angles using protractors and compass. Another irrelevant example given by a teacher was the rubric for drawing a bar graph was: "doing correct bars, labelling the x and y axis correct, writing heading, writing key is necessary." Knowledge of different assessment strategies is an essential component of teachers' pedagogic content knowledge which enables them to improve the effectiveness of their teaching. Formal testing techniques on their own cannot provide sufficient feedback to learners. Teachers may involve projects and investigations (Van den Bergh, Mortelmans, Spooren, Van Petegem, Gijbels, & Vanthournout, 2006) , as well as formative assessments as the way of improving teaching and learning about

learners' update of work presented (Black & Wiliam, 1998). From the results above, it can be noted that the teachers in our sample, cited only one approach in teaching and assessing mathematics and statistics topics. Perhaps the teachers used different approaches but only mentioned one approach. However it is also possible that the teachers are accustomed to only one approach. Ball et al. (2008, p.400) give some examples of skills that a mathematics teacher should possess. For instance, teachers who teach mathematics must be capable of selecting representations for particular purposes and presenting a topic using various approaches. It is therefore important for teachers to understand the use of more than one method in order to teach mathematics and statistics competently.

4.3.4 Demographic Factors

In this section, I explore some demographic factors which may influence teacher's decisions to use multiple teaching methods and assessments strategies. These factors were given in Table 1. I then grouped teachers' answers into two categories, those teachers who expressed a single method or single assessment and those who expressed at least two or more (multiple) methods or multiple assessments, as shown in Table 4.4. These two response variables were modelled using binary logistic regression (Harrell, 2015; Hellevik, 2009) at significant level $\alpha = .05$. SAS 9.4 (SAS Institute Inc., 2014). The description of the response variables is also presented in Table 4.4.

4.3.5 Fit Statistics

In order to assure goodness of fit, I first checked with three chi-square tests such as likelihood ratio, score and Wald Test in order to guarantee that at least one of the predictors' regression coefficient is not equal to zero in the model.

Table 4. 4 Description of the responses variable

Category	Responses variables	Codes (binary)	Total
Teaching methods (Model 1)	Single	0	36 (48%)
	More than one	1	39 (52%)
Assessment strategies (Model 2)	Single	0	44 (58.7%)
	More than one	1	31 (41.3%)

Table 4.5 indicates that all p -values from the all three tests are small ($< .05$); this leads us to conclude that at least one of the regression coefficients in the model is not equal to zero.

Table 4. 5 Testing Global Null Hypothesis: Beta (β) = 0

Teaching methods				Assessment strategies			
Test	Chi-square	df	p-value	Test	Chi-square	df	p-value
Likelihood ratio	18.864	6	.004	Likelihood ratio	21.316	6	.002
Score	17.222	6	.008	Score	18.360	6	.005
Wald	14.201	6	.027	Wald	13.624	6	.034

Note: *df* = Number of factors included in the model.

The Hosmer and Lemeshow (H-L) Test (Hosmer & Lemeshow, 2000) was also used. The finding from Table 4.6 indicates that the *p*-values of H-L test are large and non-significant (the values are greater than .05). This indicates that the model fits the data.

Table 4. 6 Hosmer and Lemeshow Goodness -of -Fit test

Teaching methods (Model 1)			Assessment strategies (Model 2)		
Chi-square	df	p-value	Chi-square	df	p-value
3.647	7	.819	1.622	7	.977

Note: *df* = Number of groups -2 (nine groups computed).

4.3.5 Parameters Estimates from Logistic Regression Model

I present the parameters estimates of each factor explored in Table 1 (methodology) in order to identify the effect of each factor in the model. These factors include gender, age, experience, level of education, using curriculum Grade R-12 and the attendance of professional courses. The parameters estimate of these factors, are presented in Table 4.7 and Table 4.8. It was only reported those with significant *p*-values ($p < 0.05$).

Gender

There is a statistically significant difference with respect to gender and the use of different types of teaching methods. It is observed from Table 8 that female teachers are more likely to use single method of teaching than males ($OR = .158$, p -value = .003) compared to male teachers, i.e. female teachers are more likely to use a single method of teaching than males are. This finding seems to be new, because gender differences in teaching practices do not appear to have been studied. This finding

suggests that male teachers are more likely to be trying different methods; it could mean that male teachers may just be more confident about reporting their teaching and assessment practices.

Familiarity with the curriculum

Becoming more informed about the curriculum itself has positive effects on teachers' use of multiple teaching methods and assessments. I found a statistically significant difference between teachers working across the NCS Grades R-12 (2012) and the use of different types of teaching assessment. It is observed in Table 9 that the group of those who had not used NCS, is 0.272 (p -value = 0.023) times more likely to have used multiple assessment strategies than the group who has used NCS. This finding is unsurprising, because it confirms that teachers who are interested enough to consult the curriculum would be better placed to try different assessment strategies as endorsed in the curriculum documents (DoBE, 2011b).

Table 4. 7 Parameters estimates for teaching methods

Factors	Codes	β	SE	X^2	Sig.	OR
Gender (Male = ref)	Female	-1.842	0.617	8.911	0.003	0.158
Level of education (Postgraduate = ref)	Bachelor	-1.285	0.599	4.588	0.032	0.277
Intercept		0.402	9.714	0.171	0.679	

Table 4. 8 Parameters estimates for assessment strategies

Factors	Codes	β	SE	X^2	Sig.	OR
Age (> 40 = ref)	≤ 40	1.670	0.825	4.091	0.043	5.309
Teaching experience (> 10 = ref)	≤ 10	1.713	0.832	4.235	0.039	5.543
Attended mathematics or statistics workshops (Yes = ref)	No	-2.582	1.115	5.368	0.021	0.076
Use NCS grade R-12 (used = ref)	Not used it	-1.302	0.573	5.152	0.023	0.272
Intercept		-0.902	0.995	0.821	0.365	

OR = Exponential function of the regression coefficient (β), is the odds ratio associated with a one-unit increase in the exposure.

Age and teaching experience

The study found a significant difference between teachers' age and the use of different assessment strategies. It can be noted from Table 9 that teachers ≤ 40 years old are more likely to use more than one assessment strategies ($OR = 5.309$; p -value = 0.043) compared to teachers aged > 40 years old. Besides, the finding indicates a significant difference between teaching experience and the use of teaching methods and assessments strategies. Table 9 indicates that teachers whose teaching experience is ≤ 10 years are more likely to use more than one assessment strategies ($OR = 5.543$; p -value = 0.039) compared to teachers whose teaching experience is > 10 years respectively. It is surprising that less experienced teachers are more likely to use more than one assessment compared to more experienced teachers. I further noted that teachers aged ≤ 40 are also more likely than older teachers to cite the use of multiple assessment methods which provides further support to the finding that younger teachers seem to be more willing to discuss their use of multiple methods of assessments. Although teacher learning is dependent on the process of increasing participation in the practice of teaching (Adler, 2000), this does not necessarily mean that more experienced teachers are more inventive than their less experienced counterparts. Kini and Podolsky (2016) note that there is variation in teacher effectiveness at every stage of the teaching career, so not every inexperienced teacher is less effective, and not every experienced teacher is more effective. They emphasise that the benefits of teaching experience will be best realised when teachers are carefully selected and well-prepared at the point of entry into the teaching staff.

Level of education

With respect to teachers' level of education, the findings indicate that those who have bachelor's degree qualification are 0.277 (p -value = 0.032) times less likely to use multiple methods of teaching than the group with postgraduate qualifications. It is possible that the teachers who have studied further have been exposed to more diverse teaching methods during their postgraduate studies, making it easier for them to experiment with different methods.

Professional learning

Professional learning was also found to be a significant factor influencing teachers to report the use of multiple teaching methods. It can be noted from Table 9 that teachers who have attended mathematics or statistics workshops related to teaching and learning are more likely to report the use of multiple assessment strategies than those who did not attend these workshops ($OR = 0.076$, $p\text{-value} = 0.021$). This finding suggests that those who acquired some professional courses in teaching mathematics and statistics are more likely to apply multiple assessment strategies than those who did not do so. Kini and Podolsky (2016, p.1) emphasise that teachers who enter the professional tier of teaching have met a competency standard from which they can continue to expand their expertise throughout their careers.

Based on these findings, it is recommended that teachers be given support in developing more effective approaches that could stimulate their learners' creativity, and increase their interest. Such support could help teachers in teaching probability and statistics, improving the learners' graphical reasoning, and using concrete materials. Ultimately, the teachers would be increasingly able to apply a variety of approaches in order to help today's learners prepare for tomorrow's world, as reported in Steen (2001).

Moreover, teachers are encouraged to develop projects which develop learners' abilities and skills to apply mathematics to real-life situations (DoBE, 2011b). More specifically, as suggested by North et al. (2014, p.4), additional resources and additional programmes are required in order to build in more aspects of statistical literacy in teacher education programmes. A further need, identified by North et al. (2014, p.24), is to include teachers in small-group work or in extended open-ended discussions, so that they can practise the use of these types of teaching methods, while also developing a deeper understanding of the concepts of statistics. However, it remains a challenge to find such time in teacher development programmes that are offered by higher education institutions (North et al., 2014, p.18). The alternative is to offer in-depth teacher support programmes at the schools where teachers work, so that they can learn while they teach.

The findings show that most teachers are not applying multiple teaching methods and assessments approaches which are necessary to prepare learners to participate in a developing economy. Meeting the requirements of a global economy involves

inculcating 21st century skills, and teaching as well as assessments must draw upon creative learning practices.

4.4 Conclusion

In this chapter, I used the teachers' responses to a questionnaire to analyse how likely they were to use more than a single method and assessment to teach mathematics and statistics. This study was intended to bring new insight into the extent to which progressive approaches are being implemented in relation to developing learners' understanding of mathematics. I found that the teachers seemed to be more comfortable in using a single approach in teaching statistics topics than in applying multiple methods. The teaching of statistics can be made more interesting by the use of real life examples such as media reports and newspapers articles in the classroom. These readily available resources can be used to develop learners' aptitude in terms of interpreting statistical ideas. Teachers could also build in opportunities of working with real data sets and simulated computer based activities, since statistics has so many real-life applications. Such activities could help learners explore statistical concepts while engaging in data collection and analysis. The use of these innovative pedagogies can promote statistical thinking, reasoning and construction of their knowledge.

The findings revealed that teachers did try to engage in progressive methods such as classroom discussion, group work and practical examples in their classrooms; however, teacher-led instruction methods were still their first choice. The findings also show that teachers need to build up their repertoire of formative assessment strategies which will help them to provide regular feedback in order to enhance the learning experiences of their learners. For example, it would be useful to integrate projects, simulations, and investigations as they develop learners' reasoning in mathematics and statistics. The results of this study show that much work is needed before teachers can take on the variety of methods to the same extent that they use formal assessments. It is therefore incumbent upon the Department of Basic Education to explore possible classroom-based interventions that can encourage teachers to start increasing their repertoire of assessment strategies. This suggests that teachers may need some support in trying to move to more innovative methods which can enable learners to express themselves. The study has shown that teachers who attend

workshops are more likely to cite several assessment methods than those who do not. This is an illustration of the value of attending professional development courses. To encourage teachers to attend more professional development programmes, these should ideally be carried out at the places where teachers work, so that they can learn while they practise and can be supported as they try to implement more progressive teaching methods.

Through the professional development support programmes teachers can be given practical advice on how to design and assess projects using real data that they start using mathematics and statistics to solve problems in real life. The use of these methods can improve learners' critical thinking, reasoning, self-discovery and investigation skills. These different approaches will enable learners to look at different ways of finding solutions to mathematical and statistical tasks. This study further brought a new understanding that teachers' tendencies to use different teaching approaches and assessments differs according to their gender, age and teaching experience. This means that all teachers of the same age, gender and teaching experience do not have the same pedagogical knowledge and confidence to integrate different methods into their teaching and learning. This underlines the importance of teachers taking on further studies in education to ensure that they become familiar with the curriculum.

Teachers who used the national curriculum documents seem to have become aware of the need to improve their teaching by applying multiple methods in mathematics and statistics discourse. It is believed that this study has identified particular areas where teachers' teaching and assessment practices can be improved, as well as factors which are associated with progressive practices. The next chapter focuses on the ways in which teachers work across the curriculum in order to contribute to learners' understanding of mathematics and statistics concepts.

CHAPTER V. EXPLORING TEACHERS' DESCRIPTIONS OF THE WAYS IN WHICH THEY WORK WITH THE CURRICULUM IN TEACHING MATHEMATICS AND STATISTICS

5.1 Introduction

The South African curriculum policy landscape has undergone many shifts since the demise of apartheid in an effort to create a curriculum that can be used to prepare learners to compete in the global economy. Since 1994, various curriculum waves have brought changed expectations of what and how teaching and learning should take place for quality education to be achieved (Le Grange, 2010). Initially the Interim Core Syllabus was introduced as a common curriculum across the 18 departments of education that were functioning in the apartheid era. Then, in 1997 Outcomes Based Education (OBE) was introduced as part of Curriculum 2005 (C2005) (Taylor & Vinjevold, 1999).

In an effort to move away from the existing curriculum perspective, C2005 set out a reform-oriented perspective modelled on curricula used in highly developed countries, whose implementation required experienced and well-trained teachers (Le Grange, 2010). The C2005 curriculum presented teachers with much freedom in deciding what could be done in their classroom, as long as it led to some broad expected outcomes. This curriculum viewed the teacher as being a professional who would be able to exercise his/her own judgement in deciding what could be taught, how it could be taught and when it could be taught. However, many studies reported that, instead of exercising the freedom to develop innovative teaching strategies, most teachers were instead teaching content of very low cognitive demand (Bansilal, 2006). Thereafter, in 2002, the curriculum was reconstructed into the Revised National Curriculum statements introduced in 2004 (Grussendorf, Booyse, & Burroughs, 2014) as a policy statement representing teaching and learning in the Further Education and Training (FET) band. In 2012, the National Curriculum Statement: Curriculum and Assessment Policy Statements was introduced, and is commonly referred to as the Caps curriculum (DoBE, 2011). In comparison to the previous curriculum, the CAPS curriculum is very structured, with specific content descriptions, and also stipulates details related to time allocation, sequencing, pacing and assessment methods

(DoBE, 2011). It is therefore important to establish to what extent and in what ways teachers really take account of this more detailed curriculum documentation.

Phaeton and Stears (2017) argue that it is helpful to conceptualise the curriculum as consisting of different curriculum levels so that analysis and understanding of the curriculum can be made more specific. The labels used by researchers differ depending on which the subject domain is being perceived. Curriculum theory commonly distinguishes between the intended curriculum (plans and activities that prescribe what should happen in schools), the interpreted curriculum (by teachers and textbook writers), the implemented curriculum (actual instructional practices) and the attained curriculum (competencies and attitudes learners demonstrate as a result of the teaching and learning process) (Phaeton & Stears, 2017; Van den Akker, 1998)

The focus of this chapter is on the intended curriculum, and the interest of this study is on the alignment between the intended and interpreted curriculum as I explore teachers' perspectives of how they work with the intended curriculum. I use the phrase "working with the curriculum" to broadly capture how teachers perceive the ways in which they work within particular and across different subject domains. I also examine whether teachers' demographic factors are related to teachers' levels of use of the intended curriculum. The inclusion of demographic information helps us to test, for instance, which group between experienced and non-experienced teachers is more likely to use the intended curriculum.

5.2 Literature Review

Studies in the area of curriculum theory usually focus on different aspects. The intended curriculum refers to written descriptions of what should happen in schools and are drawn up by curriculum designers (Aikenhead, 2006). I view the interpreted curriculum as the interpretations of the intended curriculum consolidated in, for instance, lesson plans and textbooks. The implemented curriculum describes the enactment of the interpreted curriculum in the classrooms (Mills & Treagust, 2002) and the attained curriculum refers to the competencies and attitudes demonstrated in

formative and summative assessment (Van den Akker, 1998). These researchers point out that the extent of the alignment between the intended curriculum and what happens during the implementation process ultimately affects the attained curriculum.

Bertram (2012) notes that the field of curriculum reform has provided a fertile ground for researchers in South Africa in recent years, with numerous studies trying to explain the poor results represented by the attained curriculum. Some explanations refer to poor mathematics teacher knowledge and teaching strategies (Motshekga, 2016; Spaull, 2013), incorrect interpretations of curriculum policy (Mattson & Harley, 2003) and others point to issues such as delayed pacing, limited curriculum coverage and low level of cognitive demand of lessons (Reeves, 2005; Stols, 2013) as well as school functionality (Taylor, 2011).

Across many studies, the consensus seems to be that South African mathematics teachers are struggling with implementing the school mathematics curriculum (Motshekga, 2016; Wessels, 2008). Some studies point out that mathematics is poorly taught by teachers who are not able to answer the questions in the curriculum they are teaching (Bohlmann, Prince, & Deacon, 2017; Pournara, Hodgen, Adler, & Pillay, 2015; Spaull, 2013). This means that “as time goes on, children fall further and further behind the curriculum leading to a situation where remediation is almost impossible in high school since these learning gaps have been left unaddressed for too long” (Spaull, 2013, p. 6). Pournara et al. (2015) argue that poor teacher training and insufficient resources have been the main obstacles which limit the implementation of the curriculum in schools across various subject areas. The poor training created a significant content knowledge gap between the knowledge teachers developed during their own schooling and teacher training and the knowledge they need to teach the content adequately (Ngxola, 2012). Hence teachers are unable to perceive links between different parts of the curriculum (Ngxola, 2012).

Some studies in mathematics education focused on the role of statistics in the curriculum revision process. Statistics, which forms a large part of the mathematics curriculum in the current policy, was traditionally not emphasized until the revisions were implemented in the curriculum C2005. The increased emphasis on statistics justified investigations and interpretations of situations which require the use of

statistical techniques (North & Zewotir, 2006). However, because teachers had little statistics background before C2005 was introduced, much effort is still needed to help teachers to teach the statistics introduced in the new curriculum (North & Zewotir, 2006).

5.2.1 Teachers' knowledge of curriculum

The important role played by the knowledge of curriculum is seen by the fact that it comprises a distinct component in Shulman's seminal work (Shulman, 1986) on teacher knowledge. Shulman's elaboration of various categories of knowledge that are indispensable to the work of teaching acknowledges one of the domains as curriculum knowledge. Shulman (1986) explains that curriculum "is represented by the full range of programmes designed for the teaching of particular subjects and topics at a given level, [and] the variety of instructional materials available to those programme materials in a particular circumstance" (p.10). It provides guidance on the teaching programmes, teaching plans and methods to enable the process of learning.

In teaching mathematics, Ball, Thames and Phelps (2008) also emphasized the role that curriculum knowledge plays in teaching mathematics. One of their domains of pedagogic content knowledge in their model of mathematical knowledge for teaching is knowledge of content and curriculum (KCC). These authors point out that "Many tasks of teaching can be exploited as fruitful sites for inquiry and learning: selecting and developing curriculum materials, planning instruction, and assessing student work" (p.403).

It is important to note that teachers' knowledge of curriculum includes knowledge of content and analogous materials in other subjects (Shulman, 1986), that is, it should also include knowing the various approaches and topics that are found across a programme within which a course or subject resides. Shulman suggests that teachers' curriculum knowledge should go further than just having an awareness of the diverse programmes and materials for the given contexts. In his study, Shulman identifies two dimensions of curriculum knowledge, namely vertical curriculum and lateral (horizontal) curriculum.

The vertical curriculum relates to the "topics and issues that have been and will be taught in the same subject area during the preceding and later years in school" (Shulman, 1986, p. 10). It is noteworthy that the CAPS curriculum document has made

the vertical curriculum more explicit by providing an overview of topics across phases (DoBE, 2011, p. 11). Because certain concepts and skills seem to be similar across two or three successive grades, the document “gives guidelines on how progression should be addressed in these cases” (DoBE, 2011, p. 11). In mathematics, teachers who pay attention to the arrangement and sequencing of concepts across the vertical curriculum will have a deeper understanding of some of the big ideas that underpin concepts in mathematics. Big ideas in mathematics could refer to overarching concepts that bring together numerous little ideas, such as functional relationships, which can be studied in early grades as part of pattern explorations. Maoto, Masha and Maphutha (2016) recommend that learning mathematics should focus on generating ideas, where each lesson follows from and leads consistently to the next, instead of covering detail again and again. Big ideas serve to make connections across the topics and therefore effective teaching would make these connections explicit, meaningful, accessible, expandable and transferable (Maoto et al., 2016).

In contrast, lateral (horizontal) curriculum knowledge embraces the knowledge of “teachers’ ability to relate the content of a given course or lesson to topics or issues being discussed simultaneously in other classes” (Shulman, 1986, p. 10). Hence, horizontal alignment of curriculum is therefore a way in which mathematics ideas are exchanged, co-informing and interconnected. The use of the horizontal curriculum helps learners clarify how skills learned in one mathematics subject discipline do not occur or develop in isolation, and that mathematics subject disciplines are in multiple ways co-constructing or at least co-informing. Integration across subjects is important as it can show case the mutual relevance of disciplines to each other, by developing connections while aiding the development of student criticality (Johnston, Riordain, & Walshe, 2014). Some of the benefits of integration include increased motivation and engagement of students and an appreciation of applications of mathematics to concepts from other subjects. Jacobs (1993, p. 301) advises that mathematics teachers who are interested in integrating across the curriculum should have a good working knowledge of the curriculum of the other disciplines otherwise the integration effort may deteriorate into a “potpourri of random experiences”.

5.3 Results and discussion

In this section, I first present the findings regarding the suggestions given by teachers about how they work across the curriculum and then I examine the factors associated with the use of the curriculum policy document.

5.3.1 Teachers' strategies about working across the curriculum

The topics chosen by teachers included fractions, ratio, algebra, inference, statistical graphs and equations. These topics were then categorised in terms of whether they were a part of statistics or a general mathematics topic. Table 5.1 indicates the choice of topics by teachers who were teaching in the General Education and Training (GET) and Further Education and Training (FET) bands. Note that FET describes teachers who teach from Grade 10-12, and GET indicates teachers who teach from Grade 4-9 in this study.

Table 5. 1 Choice of topics by phase

Grades	Topics	Frequency
GET teachers	Mathematics	17 (22.7%)
	Statistics	9 (12.0%)
FET teachers	Mathematics	29 (38.7%)
	Statistics	20 (26.7%)
Total		75(100%)

The results in Table 5.1 show that, irrespective of the phase, teachers preferred mathematics topics over statistics topics. This is probably related to the fact that the teaching of statistics was expanded in schools only after the introduction of C2005. Prior to this, the treatment of statistics in schools was limited and mathematics teachers had little or no training in the teaching of statistics concepts (North & Zewotir, 2006). The revisions implemented in C2005 were expanded further in the new curriculum (2012) with a focus on investigating and interpreting situations which require the use of statistical techniques (North & Zewotir, 2006). However, it seems that teachers require more help so that they can teach statistics comfortably.

I now describe in more detail the various strategies provided by teachers about how they work across the curriculum to enhance students' understanding. The teachers' responses were coded into seven categories which are described in detail and

summarised in Table 5.2. The data also revealed information about the teachers who were more likely to present such strategies and these additional details are presented under each category.

Table 5.2 Teachers' perceptions on the ways on which they work across the curriculum

Code	Description	Frequency (%)
No Answer (NA)	Teachers report no ways of working across the curriculum	14 (18.6)
Unrelated suggestion (US)	This part includes teachers' answers that were unrelated to the question	10 (12.0)
Vertical Curriculum (VC)	Teachers make suggestions about how the topic is connected, or could be connected to other mathematics topics within topics,	11(14.7)
Horizontal Curriculum (HC)	Teachers make suggestions about how the topic is connected, or could be connect to other school subjects.	13 (17.3)
Real life (RL)	Teachers make suggestions about how the topic is connected, or could be connected to real life contexts	7(9.3)
Consulting textbooks (COT)	Teachers make suggestions about consulting textbooks or other documents to find connections	3(4.0)
Other teaching strategies (OTS)	Teachers make suggestions about using various strategies to enhance learners understanding.	18(24.0)
Total		75(100)

No answer (NA)

There were 14 (18.6%) teachers who did not report in any way in terms of working across the curriculum. Nine of these teachers were aged ≤ 40 years old, suggesting that they found it harder to make links across the curriculum than the older teachers who were likely to be more experienced. Furthermore, 11 of the 14 teachers who did not give a response taught in the FET grade and chose statistics topics such as tally table, probability and range, while only 2 of these teachers were teaching in GET and chose topics such as range and tally table. This distribution shows that FET teachers found it harder to describe specific links across the curriculum than their GET counterparts. It may be that these are issues that the teachers have not reflected on previously so they may have found it difficult to present a strategy spontaneously. Perhaps if they were probed about it, they may be able to identify some of their strategies.

Unrelated suggestion (US)

This category contained 10 (12.0) responses that were classified as unrelated to the question. The topics chosen by nine of these teachers were bar graphs, mean, median, mode and range and fractions, etc.; e.g. one teacher wrote “curriculum designers should be embraced in teaching” when talking about the topic of percentages. It seems as if these responses were provided without really engaging with the topic or issue. One of the concerns of the minister of education Motshekga (2016) is that mathematics is taught poorly in South Africa schools because teachers themselves are not able to answer the questions included in the curriculum. These responses suggest that some teachers are not aware about how the curriculum could assist them more specifically in their teaching.

Suggestions related to Vertical Curriculum alignment (VC)

In the category Vertical Curriculum, I considered suggestions made by teachers about how the topic is connected, or could be connected, to other mathematics topics within the curriculum. The findings show that only 11 (14.7%) teachers mentioned vertical curriculum alignment by referring to content, skills or big ideas running between different grade levels. An example of a strategy given by a teacher who focused on the topic algebra is: “Relate to previous year’s algebra work and relating to future algebraic work. Let them see progression.” It is of interest to note that these 11 teachers were ones who chose mathematics topics only, again suggesting that these teachers are more comfortable with pedagogical discussions centred on mathematics rather than statistics-specific topics. Furthermore, I found that all 11 of the suggestions were made by teachers who reported that they attended workshops on the teaching of mathematics.

Shulman (1986) suggests that teaching which takes note of vertical alignment helps students pass easily from one learning context to the next so that learning can be productive. The teachers who provided vertical alignment suggestions constitute only 14% of the group, showing that many teachers are not easily able to discuss links between previous and future teaching and learning, especially in teaching statistics topics. In the new curriculum, the issue of sequencing is more prominent than it was in C2005 (DoBE, 2011b), so it is hoped that teachers will be able to recognise how mathematics concepts progress across different levels. Maoto et al. (2016) argue that

good mathematics teaching should be about making the big ideas that connect mathematics concepts explicit and meaningful. The results here suggest that teachers may need more professional development opportunities focused on unpacking these connections.

Suggestions related to Horizontal Curriculum alignment (HC)

In this category, I considered teachers' suggestions about how the topic is connected, or could be connected to other school subjects. There were 13 (17.3%) teachers whose comments were related to the horizontal curriculum which consists of creating cross-disciplinary linkages between outcomes, assessment and curricula. In this category, as in the case of the VC category, most (11 out of the 13) teachers preferred to discuss mathematics topics instead of statistics-specific ones. Some of the mathematics topics were exponents, algebra, ratio, percentage, etc. One teacher explained that concept ratio could be related to many subjects: "Ratio of marks awarded in essay [compared] to longer transactional writing, etc. Ratio scales in geography, ratio in equations, ratio in chemistry"

I also found that 12 of the 13 teachers who made HC suggestions have attended workshops on the teaching of mathematics. As noted by Jacobs (1993), teachers who want to use integration need to know the curriculum well so that they can identify areas which could lead to productive and not superficial learning experiences.

Descriptions of other teaching strategies (OTS)

This category consisted of descriptions about using various strategies to enhance learners' understanding. Surprisingly this was the category which had the most responses 18 (24%). An example of a typical response in this category is where the teacher chose the topic fractions and wrote "Engage the whole class in discussion and interactions and working in groups". Other suggestions were about teaching in groups, using extra classes, using discovery methods, or doing homework. These responses show that the teachers did not understand what the phrase working across the curriculum referred to. Of interest is the fact that most of these suggestions were made by teachers who chose statistics topics and were also more likely to be ≤ 40 than over 40 years.

Consulting textbooks and other documents (COT)

Responses in this category were about the curriculum policies, curriculum support documents or textbooks that they would refer to, to help them find the connections. In these responses, of which there were 3 (4.0%), the teachers did not specify the nature of the connections they would look for.

Strategies related to making links to Real Life (RL)

Responses in this category were suggestions about how the topic is connected, or could be connected, to real life contexts. This category is different from the HC category which specifies links between subjects in the school curriculum. There were 7 (9.3%) who reported the use of real life to enhance student understanding. An example of an RL response related to the teaching of measurement is: “They must visit or observe the brick layers/builders) [to see] how they build houses accurately”. Hence, this teacher was providing a real life application of measurement. These responses suggest that the teachers recognise that their students need to know the “why” and “what” behind the concepts being taught. Real life activities involve inquiry skills, creativity, and critical thinking to solve problems. Kemp and Hogan (2000) articulate that quality education is one which promotes and improves student learning across the curriculum to prepare learners for lifelong learning.

These findings convey the impression that teachers’ levels of use of the curriculum is low. If the curriculum is not consulted, lesson planning will not be done effectively, and teachers would be more likely to use their routine approaches, which may result in students being bored with mathematics. It is therefore important for teachers to consult the curriculum so that they can be updated about new approaches indicated in the curriculum document.

5.3.2 The role of demographic factors in teachers’ use of the curriculum

I now examine teachers’ use of the NCS Grade R-12 in teaching mathematics and statistics topics and whether this appears to be moderated by certain factors. In order to assess the factors associated with the use of curriculum, I used binary logistic regression model, as explained in data analysis.

Table 5.3 indicates the description and frequency of the categories in the response variable. It is noted from the table that 40.0% of the teachers reported that they did not use the curriculum whereas 60.0% of them use it.

Table 5. 3 Description of the response variables

Category	Response variables	Codes	Frequency	Percentage
Using National Curriculum Statement Grade R-12	Not used it	0	30	40.0
	Used it	1	45	60.0

Results from the logistic regression

Model fit

In order to assure the goodness-of-fit for the model of using curriculum, the omnibus test statistic was used to assess whether there was a linear relationship between the probabilities of using curriculum and the demographic factors. An omnibus test statistic p -value less than 0.05 implied that the logistic regression could be used to model the data. Table 5.4 indicates that chi-square values of all three tests are the same (54.942) and their probabilities are less than 0.05. This indicates that at least one of coefficients of the predictors is not equal to zero.

Table 5. 4 Omnibus tests of model coefficients

		Chi-square	df	Sig.
Step	Step	54,942	7	0,000
1	Block	54,942	7	0,000
	Model	54,942	7	0,000

Furthermore, Hosmer-Lemeshow (H-L) goodness-of-fit statistics (Hosmer & Lemeshow, 2000) was also used to assess the model fit. This test compares the predicted values against the actual values of the dependent variable. The method is similar to the chi-square goodness-of-fit. A very small chi-square of H-L test statistic is desirable and a p -value greater than 0.05 indicates that the model is acceptable (Hosmer & Lemeshow, 2000). The findings reflected in Table 5.5 indicate that the chi-square values of H-L test and non-significant p -values (the values are greater than 0.05), which indicates the goodness of fit of the models.

Table 5. 5 Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	2,902	7	0,894

where df = number of groups -2

Model summary statistics were checked in Table 5.6. It is noted that Nagelkerke's R² is 0.702, which indicates that the models is good.

Table 5. 6 Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	46.009 ^a	0,519	0,702

Parameters estimates

The table 5.7 below presents the parameter estimate of demographic factors fitted with teachers' use of the curriculum.

Table 5. 7 Using curriculum by demographic factors

Factors	code	β	S.E.	Wal d	Sig.	Exp(β)
Age (>40=ref.)	≤40	-2,476	0,946	6,855	0,009	0,084
Met with a local group of teachers to study and discuss mathematics and statistics teaching on a regular basis (Yes=ref.)	No	-1,803	0,808	4,982	0,026	0,165
Attended previous mathematics workshops (Yes=ref.)	No	-2,556	0,795	10,334	0,001	0,078
Constant		2,721	1,211	5,048	0,025	

Table 5.7 shows that teachers aged > 40 years old are more likely to use the curriculum document than those aged ≤40 years old (p-value = 0.009, OR = .084).

A further significant finding is related to teachers' participation in professional development activities. The two different forms of professional development that were considered were attending mathematics workshops and meeting regularly with a local group of teachers to study and discuss mathematics and statistics teaching. The findings show that teachers attended previous mathematics workshops, are more likely to use the curriculum than those who did not attend them (p-value = 0.001, OR = 0.078). Furthermore, teachers who met with a local group of teachers to study and

discuss mathematics and statistics teaching on a regular basis, are more likely to use the curriculum than those who did not (p -value = 0.026, OR = 0.165). It is likely that the mathematics teacher workshops or group meetings involve discussions about curriculum issues, which may explain the positive relationship. The findings from logistic regression tell us that participating in professional courses related to teaching and learning could motivate teachers to use curriculum.

5.4 Conclusion

In this study focusing on the use of the interpreted curriculum by teachers, I examined the strategies cited by teachers about how they worked across the curriculum to improve the teaching and learning of mathematics and statistics concepts. Of great concern is that only 55% of teachers indicated that they used the curriculum. Furthermore, the study showed that almost one-third (32%) of the group gave no response or gave an unrelated description, thereby suggesting that they had little idea about how they could integrate the curriculum in mathematics teaching and learning. Furthermore, the study found that the most common response by almost one-quarter of the teachers was a description of the strategy used to teach a particular concept. There were 11 descriptions related to vertical curriculum issues which looked at the topic in relation to other mathematics or statistics topics. Thirteen other suggestions considered broader aspects of how the topic could be related to other subjects (horizontal curriculum). It is encouraging that some teachers perceive links within the vertical as well as links across the horizontal curriculum which are important drivers of quality education.

However, it is a concern that most teachers were unable to perceive ways of working within and across the curriculum. Teachers are the ones who work directly with students, who translate and shape curricular goals and theoretical ideas into classroom practice and hence they need to develop and grow in ways that will serve all their students well (Timperley, Wilson, Barrar, & Fung, 2008). The findings of the study indicate that training about the use of curriculum is urgently needed so that teachers can link content knowledge and pedagogical skills to support the curricular specifications (Ball et al., 2008). There is, therefore, a need for teachers to learn more about the curriculum upon which their practices are developed. This suggests that professional development agencies need to consider ways in which curriculum

discussions can be made part of interventions. The study also showed that teachers' extent of usage of the curriculum was moderated by the age factor. The study also showed that most of the teachers who were unable to provide descriptions of how they worked across the curriculum were young teachers (≤ 40 years). These findings suggest that as teachers gain more experience they learn more about the curriculum and are more likely to consult and understand it.

The findings in this study show that there is a statistically significant association between teachers' participation in professional development activities and their propensity to use the curriculum. This indicates the importance of participation by teachers in regular professional development activities even if it is as simple as meeting with local teachers to discuss issues about teaching and learning of mathematics. Thus, this study confirms that if teachers get more training about the curriculum they become users of it.

In the next chapter, I examine teachers' level of confidence in teaching most of mathematics and statistics topics, and their beliefs about teaching and learning mathematics and statistics.

CHAPTER VI. TEACHERS' CONFIDENCE AND BELIEFS IN TEACHING MATHEMATICS AND STATISTICS CONCEPTS

6.1 Introduction

It is commonly agreed that teachers' confidence in teaching mathematics and their beliefs about the nature of mathematics are important components of their teaching practices. Beswick et al. (2006) note that beliefs aligned with the perspective that mathematics is fun are consistent with a constructivist view of learning. They argue that the word 'fun' denotes more than enjoyment in mathematics, but includes a degree of confidence and pleasure in doing mathematics. Graven (2004) declares that

“confidence (including mathematical confidence) is an important learning component irrespective of the level of competence that one brings to the learning process because it contributes to one's becoming a life long learner within the profession of mathematics education” (p.205).

Teachers who believe that mathematics is fun are able to teach more effectively (Protheroe, 2008). Since confidence and beliefs play such a crucial role in teachers' practices, studies that focus on this area make an important contribution to the field of professional knowledge of teachers.

Although there have been many studies worldwide using quantitative methods to study levels of confidence and beliefs, there have been very few such studies in developing countries, giving prominence to the importance of this study in South Africa. The study is particularly relevant because of its focus on the teaching of statistics. The scope of statistics taught at school level was limited before the introduction of a new curriculum (Curriculum 2005), with the result that mathematics teachers trained prior to this date, had little or no training in statistics (North & Zewotir, 2006). These authors report that after the implementation of Curriculum 2005, students were introduced to graphical methods of data representation in the earlier grades (such as bar graphs and pictograms) and after this very early introduction to graphical displays of data, it was only in the Grade 9 mathematics syllabus that some statistics topics were introduced again. Only elementary statistical measures, namely mean, median, mode, range, variance and standard deviation were introduced.

A study carried out by Wessels and Nieuwoudt (2011) looked at the needs of Senior Phase mathematics teachers in the area of statistics, and included a focus on

teachers' confidence and beliefs. Our study, conducted with teachers who were actively teaching in Grades 4-12, focused on the teachers' confidence and beliefs with regard to teaching mathematics and statistics topics. In particular, the study sought to explore the teachers' levels of confidence in their ability to teach various mathematics and statistics topics, as well as their beliefs about the mathematics and statistics concepts that they teach. This was done in an attempt to identify factors that influence their particular levels of confidence. It is hoped that the study makes a contribution to the field of professional development of teachers by providing results about teachers' confidence and beliefs in mathematics and statistics taught in Grades 4-12 in KwaZulu-Natal schools. A further contribution of the research in this study is the instrument created for the study, which is an extension of an instrument designed by Beswick et al. (2006) by including teachers' confidence and beliefs towards both mathematics and statistics. It is generally known that mathematics teachers also teach statistics, so it is hoped that the results from this study will prove to be of value to probe issues related to the teaching of mathematics and statistics at intermediate school level.

6.2 Literature Review

6.2.1 Understanding mathematical and statistical literacy

According to Steen (2003), numeracy is used to describe the productions that work and enhance both statistics (the knowledge of data) and mathematics (the knowledge which focuses on patterns), and therefore 'numeracy' or 'quantitative literacy' describes the special skills required to interpret numbers. Quantitative literacy, as reported by the National Center for Education Statistics, may be understood to be the knowledge and skills needed for interpreting using numbers displayed in published materials (NCES, 1993). The mathematical literacy (ML) domain further includes all skills of analysing, reasoning, and communicating notions effectively in diverse situations (De Lange, 2006). ML plays a great role in relation to produce learners with an awareness and understanding of the role that mathematics plays in the modern world, as well as developing the ability and confidence to think numerically and spatially in order to be able to interpret and critically analyse everyday situations and to solve problems (DoBE, 2003).

Statistical literacy refers to the ability to understand and critically assess statistical facts and data-based opinions appearing in various mass media networks, as well as the skill to discuss the ideas about statistical figures, and the interpretation of statistical language, notions and causes (Rumsey, 2002). According to Gal (2002), literacy skills concern all statistical messages conveyed through written text (e.g., in the media) displayed in tables, graphs, or charts. These skills include the ability to organise data, to construct and display them in tables, and to work with different representations of data (Ben-Zvi & Garfield, 2004).

This study also focused on teachers' confidence and their beliefs regarding statistics by extending the study carried out by Beswick et al. (2006), which was focused on mathematics. Beswick et al.'s study involved 42 middle school mathematics teachers in Grades 5-8 and 650 students. The total number of items in their study was 38, with all items being scaled (13 regarding their confidence to teach, 11 related to mathematics and numeracy in everyday life and 14 items related to mathematics and numeracy in the classroom). The aim of their study was to investigate teachers' confidence, beliefs and their students' attitudes towards mathematics. Their findings revealed that teachers' confidence was higher in teaching measurement and space, while the lowest level of confidence was in teaching pattern and algebra. They also found that teachers expressed lack of confidence in relation to teaching fractions, percentage, decimals, ratio and proportion. In their study, they found that almost one third of the teachers expressed a lack of confidence in their ability to make links between mathematics and the key elements of the essential learnings and to assess being numerate key element against the essential learnings standards. Their study was strongly focused on mathematics. The present study involves 75 mathematics teachers who teach from Grade 4 to Grade 12, and these teachers responded to 59 mathematics and statistics items. More particularly, this research sought to add to existing knowledge by investigating a large group of teachers from a developing country (South Africa).

6.2.2 Teachers' confidence and beliefs in teaching mathematics

Teachers' confidence in teaching mathematics relates to their commitment or feeling sure about their ability, qualities or ideas in teaching mathematics (Witt, Goode, & Ibbett, 2013). Beswick (2007) claims that confidence in teaching mathematics is of

specific importance to teachers' practices, reflected in enjoyment of mathematics for its own sake. Some studies have reported that teachers with high confidence in their teaching ability were shown to produce more confident pupils (Eison, 1990; Pajares, 2005). Protheroe (2008) asserts that teachers' own feeling of confidence with regard to their teaching abilities contributes to their teaching efficiency while teachers' lack of confidence is linked by Appleton (1995) to the lack of background knowledge (Beswick et al., 2012) consider confidence as part of teachers' knowledge because "teachers' confidence and beliefs link straightforward with other aspects of knowledge" (p.136). Beswick et al. (2012) further argue that, in mathematics teaching, confidence is related to the acquisition of specialised content knowledge and pedagogical knowledge, as well as content knowledge and curriculum (p.139).

Regarding the factors that contribute to confidence building, it was found that confidence grows with "experience and professionalism" (McBer, 2000; Measels, 2004; Protheroe, 2008; Schmidt et al., 2001). Wessels and Nieuwoudt (2010) reported a similar finding that teachers who had attended a series of professional development workshops or courses in statistics became more confident. Results from O'Dwyer, Russell, and Bebell (2003) found that teacher confidence is linked to the largest increase when using technology for preparation.

A construct that is closely related to teachers' confidence is that of teachers' beliefs which also play a role in effective teaching and learning (Xu, 2012). The term 'belief' refers to the truth element, or mental state, which supports individuals in making sense of the world (Borg, 2001; Grant, Townend, Mulhern, & Short, 2010). These authors state that beliefs influence how new information is perceived, assimilated or rejected, and that teachers' beliefs are related to their pedagogical performance, i.e. due to the individual's teaching. Teachers' beliefs play an essential role in the development of their teaching practices (Richards, Gallo, & Renandya, 2001; Xu, 2012). According to Hermans, Tondeur, van Braak, and Valcke (2008), "belief systems consist of an eclectic mix of rules of thumb, generalizations, opinions, values, and expectations grouped in a more or less structured way" (p. 1500). Pajares (1992) adds that "beliefs are seldom clearly defined in studies or used explicitly as a conceptual tool", and that "belief is based on evaluation and judgment; knowledge is based on objective fact" (p. 313). Pajares also argues that teachers' attitudes about education regarding teaching, learning and learners can generally be described as teachers'

beliefs. Many mathematics researchers have emphasised the influence of teachers' beliefs on their practice. Ernest (1989) emphasised that teachers' beliefs about mathematics and mathematics teaching are the fundamental stimulus for their instructional practices while Grossman et al. (1989) asserted that any discussion on teachers' education should be accompanied by a consideration of their beliefs.

6.2.3 Confidence and beliefs in statistics teaching

Various researchers have undertaken studies related to teachers' confidence and beliefs with regard to statistics. Watson (2001) conducted a study on how primary and secondary school mathematics teachers express their confidence about teaching chance and data topics. Her instrument comprised nine items where the 43 teachers had to rate their level of confidence in teaching several chance and data topics, on a scale from 1 to 5. The findings revealed that the lowest mean score for confidence in teaching a statistics topic was generated by the teaching of odds ratios while the highest mean score for confidence in teaching was generated in relation to teaching graphical metaphors. Watson further compared the mean scores for confidence in teaching statistics topics amongst primary teachers and secondary teachers. She found that the mean scores ranged from 3.00 for confidence in teaching the concept of median to 3.92 for confidence in teaching data collection amongst primary teachers, whilst the similar mean scores ranged from 3.68 for teaching the odds ratio to 4.59 for secondary teachers. Finally, Watson found that high school teachers were more confident than primary school teachers when it came to teaching some specific statistics topics, because they generally had stronger mathematical backgrounds (Watson, 2001).

In 2010, adapting the profile instrument of Watson (2001), Wessels and Nieuwoudt undertook a study investigating teachers' statistical knowledge (data handling and probability), as well as their beliefs and confidence towards statistics, amongst secondary school (Grades 8-12) teachers in South Africa. The findings revealed that teachers were more confident in teaching most statistics topics, but showed a low level of statistical thinking related to their knowledge of the concepts. As an example, they found that the concepts of sample and average had high confidence as far as teaching goes, but as far as statistical thinking goes, related to these topics in social contexts, including newspaper articles and inquiries reports, the results were poor. In their study, they point out that professional development plays

an essential role in promoting teachers' confidence. They also highlight the fact that a half of the 90 teachers who attended a professional development course in statistics education were still teaching in the traditional formula driven approach instead of adopting a more "data driven approach"(Wessels & Nieuwoudt, 2010). In South Africa, a lack of confidence in teaching basic statistics literacy has been reported, which is not surprising given that teachers had generally had little or no training in statistics (North & Zewotir, 2006).

With regard to teachers' beliefs about the nature of statistics, Pierce and Chick (2011) reported that teachers' beliefs regarding statistics are under-developed compared to those related to mathematics. These authors further reported that, in general, beliefs in relation to teaching statistics are most influenced by beliefs about statistics. Gal, Ginsburg, and Schau (1997) and Zhang, Shang, Wang, Zhao, Li, Xu, and Su (2012) argue that attitudes towards statistics represent a summation of emotions and feelings experienced over time in the context of learning mathematics or statistics. They add that beliefs regarding statistics would involve beliefs about mathematics: whether it is it hard or easy, whether it requires innate skills, and whether it can be mastered by anyone. Many teachers believe that "statistics is all computations", statistics can be taught in the classroom by "a lot of drill and practice with textbook problems, or do a lot of talking about real-world examples", hold negative beliefs about themselves as learners of statistics or mathematics by choosing "I am not good at it, I don't have what it takes" and express beliefs about the usefulness or value of statistics and its importance in one's future life or career such as "I will never use it and don't really need to know it". In this chapter, I focus on teachers' beliefs about their own use of mathematics and statistics in everyday life and beliefs about how mathematics and statistics would be taught. There are few studies about confidence and beliefs in South Africa, thus this study will bring a new insight in terms of their confidence in the content and their beliefs about what they teach

6.3 Results

6.3.1 Teachers' confidence about facilitating the content of the topics

The results of questions related to confidence of teachers about their teaching are expressed by the mean scores for each item, as given in Table 6.1. As discussed, a high mean value indicates a high level of confidence in teaching the related topic and a low mean value indicates a low level of confidence in teaching that particular mathematics or statistics topic. Moreover, I used nonparametric test (Vickers, 2005) at significance $\alpha = 0.05$, to compare the different group of means (in Tables 6.1, 6.2 and 6.3) in order to test whether any of those means are significantly different from each other.

The p-values computed by those tests help to confirm (if p-value is less than say 0.05, confirmation of 95% certainty) whether there appears or not a statistical difference between teachers' confidence in their ability to teach different mathematics and statistics topics presented in Table 6.1 and their beliefs in their own use of and teaching mathematics and statistics presented in Table 6.2 and Table 6.3. In other words, I test the null hypotheses which suggests that all means are equal : $H_0: \mu_1 = \mu_2 = \mu_3 = \dots = \mu_n$ against the alternative hypothesis: $H_A: \mu_1 \neq \mu_2 \neq \mu_3 \neq \dots \neq \mu_n$, which means that at least one mean is different from others, where μ = group mean and n = number of groups (Stoica, 2015).

Results from Table 6.1 must be read in relation to the fact that the higher the score, the more confident the teacher. It can be noted from Table 6.1 that the teachers' confidence in their teaching varied according to the various topics being taught such as percentages (mean score = 4.000, std = 1.080), fractions (mean score = 3.945, std = 1.012), decimals (mean = 3.863, std = 1.004), and pie graphs and histograms (mean score = 3.6956, std = 1.163). Table 6.1 also shows that the means scores of teachers' confidence in teaching mathematics topics are higher (highest mean = 4.000, std = 1.080 for teaching percentages) than the means scores of teachers' confidence in teaching statistics topics (highest mean score=3.699, std= 1.163, for teaching pie graphs and histograms). These findings inform us that the teachers' confidence in their ability was not the same. This was confirmed by the results of nonparametric test, displayed in Table 6.1, which confirms that there is a statistically significant difference

between group means scores generated by the teachers' confidence in their ability to teach different topics. Table 6.1 also shows that mean scores of teachers' confidence in teaching mathematics are higher than mean scores of teachers' confidence in teaching statistics. This difference may be due to the fact that statistics is a new field and teachers are not quite used to teaching it (North et al., 2010; North & Zewotir, 2006).

Table 6. 1 Means score for teachers' confidence

Topics	Mean (N=75)	STD(N=75)	P-value²
Percentages	4.000	1.080	.000
Fractions	3.945	1.012	.000
Decimals	3.863	1.004	.000
Pie graphs and histograms*	3.699	1.163	.000
Pattern and algebra	3.685	1.104	.000
Measurement	3.658	1.030	.000
Ratios and proportions	3.521	1.144	.000
Simple probabilities understanding and calculations*	3.493	1.095	.001
Providing explicit explication in teaching mathematics	3.397	1.051	.000
Ideas of sampling and data collection *	3.302	1.010	.000
Mental computation	3.288	1.034	.000
Connecting statistics to other key learning areas*	3.261	1.155	.013
Range and variations*	3.247	1.140	.002
Using statistics outside of the classroom situation*	3.206	1.105	.002
Connecting mathematics to other key learning areas	3.151	1.114	.004
Inference and prediction*	2.863	1.004	.000
Critical debate on mathematics and statistics in the media*	2.795	1.027	.002

²P-values obtained by nonparametric test

6.3.2 Teachers' beliefs about using mathematics and statistics in everyday life

Profiles describing teachers' beliefs about their own use of mathematics and statistics in everyday life are shown in Table 6.2. The results are presented in descending order of mean score for beliefs of that statement. In this study, the highest beliefs are addressed to "I believe numeracy is becoming increasingly important in our society" (mean score = 2.946, std = 0.226), followed by "Statistical literacy, thinking and reasoning is an extremely important skill to develop in everyday life" (mean score = 2.933, std = 0.251), followed by the statement "I believe knowledge of data types,

surveys, population, samples, frequency, plots, grouping data, mean, median, mode, random experiment, probability is becoming increasingly important in our society” (mean score = 2.880).

However, teachers expressed a low level of agreement the statement “Mathematics and statistics are not always communicated well in newspapers and in the media” (mean scores = 2.280, std = 0.708). With regard to the different values of the means scores, it is evident that teachers’ beliefs about their own use of mathematics and statistics in everyday life are not the same. This was also confirmed by the results of nonparametric test, which showed a statistically significant difference between different means of the statements which emerged from teachers’ beliefs between different items regarding using mathematics and statistics in everyday situation. Items in bold type in Tables 6.2 and 6.3 were scored in reverse such that for all items high means indicate more positive ability and items marked with an asterisk (*) are related to statistics

Table 6. 2 Means score of beliefs in everyday life

Items	Mean (N=75)	STD(N =75)	P-value ²
I believe numeracy is becoming increasingly important in our society	2.947	0.226	.000
Statistical literacy, thinking and reasoning is an extremely important skill to develop in everyday life*	2.933	0.251	.000
I believe knowledge of data types, surveys, population, samples, frequency, plots, grouping data, mean, median, mode, random experiment, probability* is becoming increasingly important in our society	2.880	0.366	.000
I believe numbers and how to work with them is as essential for everyone as reading and writing are	2.853	0.392	.000
I am confident that I could work out how many tiles I would need to tile my bathroom	2.813	0.425	.000
I often perform mental calculations in my head (without a calculator)	2.813	0.425	.000
I can easily extract information from tables, plans and graphs	2.813	0.425	.000
I need to be mathematically numerate to be an intelligent consumer	2.747	0.548	.000
Given the price per square metre, I could estimate how much it would cost to carpet the lounge	2.73	0.496	.000
Proportional reasoning is needed to understand claims made in media	2.560	0.620	.000
I often use mathematics/statistics to make decisions and choices in everyday life*	2.547	0.664	.004
I do have difficulty in identifying mathematics structures (forms) in everyday situations	2.413	0.660	.000
I have difficulty in understanding statistical facts in everyday situations*	2.373	0.749	.000
Mathematics/statistics is not always communicated well in newspapers and in the media	2.280	0.708	.003

² P-values obtained using nonparametric test

6.2.3 Teachers' beliefs about teaching mathematics and statistics in the classroom

Profiles describing the statements about mathematics and statistics concerning beliefs or attitudes about teaching mathematics in the classroom are shown in Table 6.3. Mean scores are presented in descending order, with high mean scores indicating a more positive belief regarding the statement. For instance, as indicated in Table 6.3, the most highly scored beliefs are related to "Statistics teaching should assist learners in developing a positive attitude to problem solving" (mean score = 4.520; std = 0.554), followed by beliefs indicating that "It is important that mathematics content is presented in the correct sequence" (mean score = 4.467; std = 0.759), statistics teaching should assist learners in developing an attitude of inquiry (asking questions, being curious about solutions (mean score = 4.667), followed by mathematics teaching should assist learners in growing an attitude of inquiring (asking questions, being curious about solutions). However, some teachers disagreed on "Telling learners the answer is an efficient way of facilitating their mathematics learning" (mean score = 2.133). The details of all results are shown in Table 6.3. As one can see, teachers expressed different beliefs about teaching and learning mathematics and statistics topics due to the variability of the mean scores. This was confirmed by the results of non-parametric test (Table 6.3), which showed that there is a statistically significant difference from one statement to another which emerged from teachers' beliefs about teaching mathematics and statistics in the classroom.

Table 6. 3 Means score of teachers' beliefs about mathematics in the classroom

Items	Mean (N=75)	STD (N=75)	P- value ²
Statistics teaching should help learners to develop a positive attitude to problem solving*	4.520	0.554	.003
It is important that mathematics content is presented in the correct sequence	4.467	0.759	.000
Statistics teaching should assist learners in growing an attitude of inquiry (asking questions, being curious about solutions) *	4.467	0.600	.000
Mathematics teaching should assist learners in developing an attitude of inquiry (asking questions, being curious about solutions)	4.387	0.715	.016
Teachers of mathematics should be knowledgeable of the way children think and be intrigued (interested) by alternative ideas	4.293	0.851	.000
I use technology to assess mathematics learning (computers, calculators)	4.293	1.088	.000
Teachers of mathematics should be fascinated with how learners think and be intrigued (interested) by alternative ideas	4.160	1.027	.000
Ignoring the mathematics ideas that children generate themselves can seriously limit their learning	4.160	1.128	.000

Items	Mean (N=75)	STD (N=75)	P- value ²
Statistical literacy, thinking and reasoning are the main goals in statistical teaching and learning*	4.147	0.672	.000
Teaching statistics should be well-taught by the way children think and be intrigued (interested) by alternative ideas*	4.133	0.664	.000
Mathematical content is best presented in an expository style: demonstrating, explaining and describing concepts and skills	4.120	0.944	.000
Effective mathematics teachers enjoy learning and doing mathematics themselves	4.120	1.139	.012
I would feel uncomfortable if a child suggested a solution to a statistics problem that I hadn't thought of previously*	4.067	1.070	.000
Using technology helps to increase learners' learning and understanding of statistics*	4.053	0.957	.000
Justifying the mathematical statements that a learner makes is an extremely important part of learning the subject	4.040	0.861	.000
Statistical material is best presented in an expository style: demonstrating, explaining and describing concepts and skills*	4.040	0.743	.000
Effective mathematics teachers enjoy learning and doing statistics themselves*	3.933	1.119	.000
Often the statistics work I do in the classroom is not relevant to the students' everyday lives	3.907	1.093	.000
I would feel uncomfortable if a child suggested a solution to a mathematics problem that I hadn't thought of previously	3.867	1.256	.000
Allowing a child to struggle with mathematics problems, even a little tension, can be necessary for learning to occur	3.707	1.136	.000
Often the mathematics work I do in the classroom is not relevant to the students' everyday lives	3.627	1.223	.000
It is difficult to teach both statistics conceptually and procedurally*	3.413	1.028	.000
Mathematics in high school is best taught in mixed groups of abilities, at least until Grade 9	3.348	0.979	.000
It is difficult to teach statistics without a text book*	3.267	1.201	.008
It is difficult to teach mathematics without a text book	2.987	1.279	.000
Mathematics is computations	2.920	1.160	.003
Statistics is computations*	2.507	1.129	.004
Telling learners the answer is an efficient way of facilitating their mathematics learning	2.133	1.107	.016

²P-value obtained using parametric test

The results of the analysis confirm that there is a statistically significant difference in teachers' level of confidence between teaching different mathematics and statistical topics. The results indicate that there is a statistically significant difference between teachers' beliefs about their own use of mathematics and statistics in everyday life. Moreover, there is a statistically significant difference between teachers' beliefs about the importance of teaching and learning mathematics and statistics. If I look at the Table 5.1, 5.2 and 5.3, it can be noted that p-values emerged from different statements describing teachers' confidence and their beliefs are less than 0.05. Therefore, I reject null hypothesis which suggests that all means are equal and then it

can be noted that teachers do not have the same ability in relation to their confidence and their beliefs, and I am 95% sure of this result.

6.2.4 Factors contributing to confidence development

Given that teachers' confidence was the central focus of this study, I investigated whether there appear to be some factors that contribute to a positive influence on the development of their confidence in teaching statistics and mathematics topics. I investigated teachers' confidence by gender, professional learning (those who attended workshops and who did not), use of technology, as well as the level of study. The factors which were found to contribute to confidence building are attending workshops in mathematics and in statistics, level of study, and using technology in teaching and learning mathematics and statistics.

Using multivariate analysis at significant level $\alpha = 0.05$, I found that teachers' confidence in their ability was significantly different by gender ($F = 1.488$; $p\text{-value} = 0.000$). This could be seen clearly in certain topics where male teachers were found to be more confident in teaching decimals than female teachers (mean score = 4.216 for males versus 3.811 for females), percentages (mean score = 4.135 for males versus 3.784 for females) and ratio and proportions (mean scores = 3.973 versus 3.459) than female teachers (see Figure 6.1). CN1 to CN17 describes 17 confidence items reported in Table 6.2.

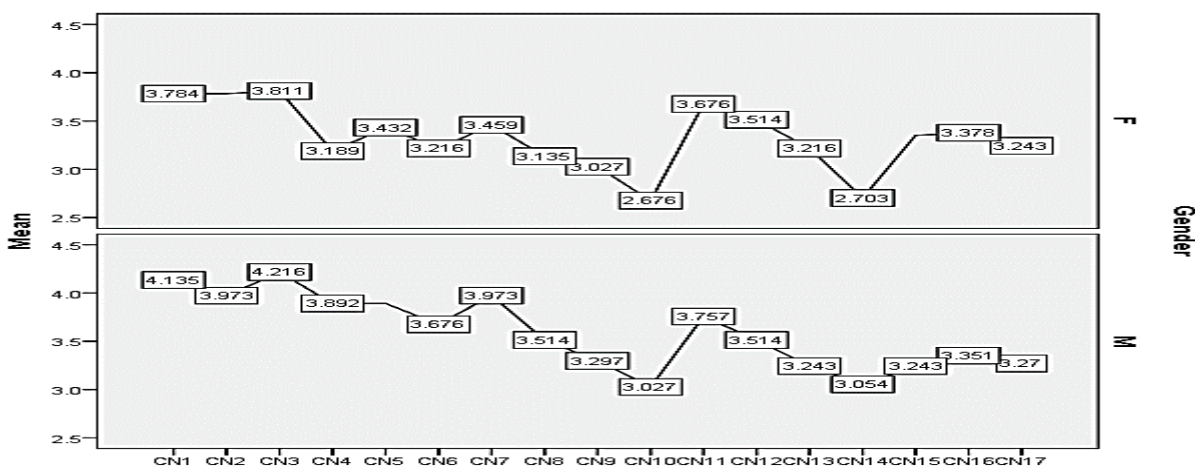


Figure 6. 1 Means plot of teachers' confidence by gender

I also found a statistically significant difference between teachers' confidence ability and their age ($F = 1.534$; $p\text{-value} = 0.000$), where using the same plot, I found that the teachers aged from 41 to 50 years old and 51 to 60 years old were more confident than young teachers. A statistically significant difference was further found between teachers' confidence in their ability and their use of the NCS ($F = 1.46$; $p\text{-value} = 0.001$), where the teachers who used and were trained on the NCS expressed a high confidence in teaching fractions, decimals, percentages and measurements than teachers who did not use it. Furthermore, I found a statistically significant difference between teachers' confidence in their ability and those who attended workshops in mathematics and those who did not attend them ($F = 1.213$; $p\text{-value} = 0.038$). I found that the teachers who attended workshops expressed a higher confidence than those who did not attend them. The teachers who attended workshops expressed a high confidence in teaching the topics of decimals, percentages and pattern and algebra, which are also topics that have been in the school curriculum for many years. Hence these are topics that the teachers are more familiar with. A statistically significant difference was further found to exist between the teachers' confidence in their ability and using technology in teaching ($F = 1.222$; $p\text{-value} = 0.034$), where the teachers who use technology in teaching mathematics and statistics were more confident than those who do not use it.

The age factor emerged as statistically significant in many items probing teachers' beliefs about teaching mathematics and statistics. Teachers aged from 51 to 60 years old demonstrated a higher belief that statistical literacy, thinking and reasoning is an extremely important skill to develop in everyday life, they demonstrate the need to be mathematical numerate to be an intelligent consumer and they believe numeracy is becoming increasingly important in our society", compared to young teachers ($F = 1.758$; $p\text{-value} = 0.000$). Furthermore, there was a statistically significant difference between teachers' beliefs in teaching mathematics and statistics in the classroom and their age ($F = 1.394$; $p = 0.002$), where the older teachers disagreed that it is difficult to teach statistics both conceptually and procedurally in contrast to young teachers.

6.2.5 Overall findings of teachers' confidence and beliefs

In this section, I present an overall picture of the teachers' confidence and beliefs about teaching and using mathematics and statistics. Tables 6.1, 6.2 and 6.3 show the individual mean scores and standard deviations to identify the topics about which the teachers are most confident. I next present the total image regarding their level of confidence and beliefs globally. Figure 6.2 indicates that 48% of the teachers expressed high confidence in teaching mathematics and statistics topics, while 31% of the teachers expressed moderate confidence and 20% of teachers expressed low confidence.

Figure 6.2 also indicates that 72% of the teachers expressed a high level of agreement that mathematics and statistics play an important role in our everyday life, whereas 20% of teachers stayed ambivalent and 7% expressed a negative belief. Figure 6.2 further indicates that 70% of teachers expressed positive belief that it is important to teach and learn mathematics and statistics, whereas 15% did not say anything and 15% disagreed about the importance of teaching and learning mathematics and statistics.

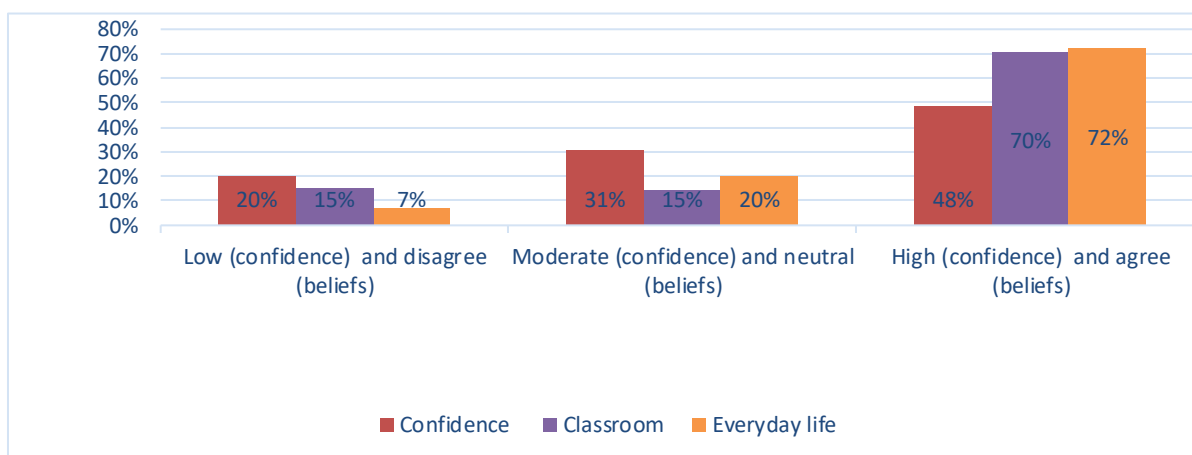


Figure 6.2 Overall representation of teachers' confidence and beliefs towards mathematics and statistics

I further examined whether there is a positive relationship between the teachers' confidence in their ability to teach most mathematics and statistics topics and their beliefs about their own use of mathematics and statistics in everyday life, as well as towards teaching and learning in general. Figure 6.2 displays the output graphs of three variables: teachers' confidence, their beliefs in teaching and learning, and their beliefs in their own use of mathematics and statistics in everyday life. It is evident that

as teachers' confidence increase, their beliefs about their use of and understanding of mathematics become stronger. This demonstrates that there is a positive relationship between teachers' confidence and their beliefs. The value of the Pearson correlation was also computed for confirmation. The value of the Pearson correlation is ($r = 0.98$ or 98%, $p\text{-value} = <0.001$) between teachers' confidence in their ability to teach mathematics and statistics topics and their beliefs about their own use of mathematics and statistics in everyday life. I also found a significant correlation ($r = 0.58$ or 58%, $p\text{-value} = <0.001$) between teachers' confidence in their ability to teach mathematics and statistics topics and their beliefs about teaching mathematics and statistics in the classroom. The findings presented above show that teachers demonstrated confidence in teaching numeracy topics, however they demonstrated a limited confidence in using mathematics and statistics in real life. This finding also reveals that teachers find it difficult to relate teaching to real life. Mathematics teachers must understand that, in order to compete in global economy, teaching must focus in solving and finding a solution to the existing problems in everyday life. This will help in understanding the importance of studying mathematics and statistics.

6.4 Conclusion

This chapter focused on teachers' confidence in their ability to teach most mathematics and statistics topics, their beliefs about their own use of numeracy and literacy skills in everyday life, and their beliefs about teaching and learning mathematics and statistics in general with regard to confidence in teaching mathematics and statistics topics. The findings revealed that 48% of the teachers expressed high confidence, while 31% of the teachers indicated moderate confidence and 20% of the teachers expressed low confidence in teaching mathematics and statistics topics.

Some results are similar to those reported by other research. The teachers showed higher confidence in teaching percentages, fractions and decimals as was found in the study by (Callingham & Watson, 2014) whose participants were 42 teachers. The results for confidence levels about linking mathematics to other key learning areas was found to be very low, as also reported by Beswick et al. (2006). The teachers' confidence about engaging learners in critical debate on mathematics and statistics in the media (such as newspapers, television and the internet), and

inference and prediction was low, as discussed in (Wessels & Nieuwoudt, 2010). These findings indicate that the teachers' confidence levels were different for different learning skills. The teachers seemed to be more comfortable with familiar topics that are taught in the classroom than those which require links to other areas as well as those which require critical engagement with the content beyond the classroom.

The findings further revealed that their confidence in teaching mathematics topics was higher than their confidence in teaching statistics topics. The findings also showed that the teachers' confidence was higher for those who attended workshops related to mathematics and statistics teaching and those who had engaged in further studies. This finding is similar to the earlier findings of other studies where it was reported that confidence grows with professionalism (McBer, 2000; Swan & Dixon, 2006; Wessels & Nieuwoudt, 2010).

Findings concerning teachers' beliefs about using mathematics and statistics in everyday life, as well as in teaching and learning, showed that the teachers had a positive view in relation to their own use of mathematics and statistics in everyday life (72.48% of agreement). Nevertheless, several teachers were neutral with regard to the statement "Mathematics and statistics are always communicated well in newspapers and in the media" and beliefs expressing that "I do have difficulty in identifying mathematics structures (forms) in everyday situations." This indicates that mathematics teachers need to be given more support about how they could apply mathematics and statistics concepts beyond the classroom. Furthermore, I found that the teachers' confidence in teaching different topics and their beliefs were not the same. This shows that the teachers had different abilities and different views about teaching these topics and about the importance of using or learning mathematics and statistics.

There further appeared to be a positive correlation between the teachers' confidence and beliefs. It is indispensable for mathematics teachers to have a combination of both these qualities to promote knowledge. Generally, this study brought new insight into the extent to which teachers express their confidence in their ability to teach different mathematics and statistics topics and further identified the fields in which they were more confident. It further emphasises the importance of using mathematics and statistics in everyday situations and why these two domains must be taught, learned and understood in the classroom. I recommend that teacher development programmes should be aimed at improving teachers' confidence in

connecting mathematics and statistics to other learning areas as well as highlighting the importance of learning mathematics and statistics using the mass media. Teachers who have a positive attitude about their role as teachers will help inspire their learners to develop confidence in mathematics and statistics. In the next chapter, I explore teachers' level for using technology in teaching mathematics and statistics concepts.

CHAPTER VII. EXPLORING THE USE OF TECHNOLOGY IN THE TEACHING AND LEARNING OF MATHEMATICS IN KWAZULU-NATAL SCHOOLS

7.1 Introduction

The rapidly growing influence of technology in the 21st century has led to calls for teaching and learning to be transformed to prepare learners to compete within the global knowledge economy. Learning in the 21st century requires the collaboration of well-trained teachers, working in well-equipped classrooms and using technology innovatively to support a constructive learning atmosphere (Molnár, 2008). Technology allows learners to move beyond focusing on basic information to more global issues by providing them with access to innovative applications and tools (Van Melle & Tomalty, 2000). The teaching environment can thus be transformed by teachers if they integrate technology effectively in preparing lessons, designing learning activities, and conducting assessments.

The potential of technology to transform the classroom is recognised by the South African Department of Education (DoE) which supports the idea of introducing Information and Communication Technology (ICT) in South African schools (DoBE, 2007, 2016a). Teachers are urged to develop learners with 'relevant modern skills that match the needs of our changing world' (DoBE, 2016a, p. 3). Learners should be able to 'access, analyse, evaluate, integrate, present and communicate information; create knowledge and new information by adapting, applying, designing, inventing and authoring; and function effectively in a knowledge society by using appropriate ICT ... skills' (DoBE, 2007, p. 3). The Education Department states that ICT can recreate a classroom atmosphere while also advancing higher-order thinking skills in learners (DoBE, 2010). For example, it enables teachers and learners to increase the level of comprehension, reasoning, problem solving, thinking and employability (DoBE, 2004, 2007). The DOE further highlights five targets of the use of ICT which involve 'entry (basic ICT skills), adoption and adaptation (integration of ICT in teaching and learning), and appropriations and innovation (specialisation and innovation in ICT education) (DoBE, 2007, p. 9). Thus, teachers are encouraged to develop their capability and innovation to make the best use of the potential of digital devices in augmenting learner

performance (Ndlovu & Lawrence, 2012). It has become incumbent upon teachers to attain relevant and appropriate ICT knowledge, and skills to be able to integrate it appropriately in teaching, learning and administration (DoBE, 2007). However, the digital divide, which is the disparity in the level of development and access to ICT between different sectors, presents a challenge to educational innovations. Insufficient basic ICT infrastructure in rural schools poses a challenge for teachers which is not necessarily the case in urban schools (Dzansi & Amedzo, 2014). Ndlovu and Lawrence (2012) emphasise that ICT policy has been poorly implemented across South African schools, more specifically for those schools which serve disadvantaged areas, thus adding to the digital divide. Many disadvantaged schools cannot keep up with the well-resourced schools in terms of integrating ICT into their teaching and learning approaches. The limited use of ICT is not simply caused by the shortage of resources, but it is dependent on the ways in which the teachers utilise the available educational tools in their teaching (Ndlovu & Lawrence, 2012). Research highlights particular teacher factors such as age, experience, confidence, beliefs, as well as gender which seem to influence the extent to which teachers take up technology in their teaching practices (Ali, 2015; Beswick, 2007; Brändström, 2011; Cavas, Cavas, Karaoglan, & Kislá, 2009; Choi, 1992).

This study addresses the use of technology in teaching mathematics and statistics. Recent advances in technology have unlocked entirely new directions for education research. In this study, I try to make a contribution towards finding out more about the use of technology in KwaZulu-Natal schools. The study also explores the relationship between teachers' use of technology and their confidence and beliefs about the ways in which mathematics should be taught. To our knowledge, no previous study has focused on these issues. Furthermore, the study looks at the factors which may have a relationship with the use of technology. It is hoped that the knowledge contributed by this study will help the Education Department in their planning and provision for teacher support in the use of technology. I also hope that this study will help other researchers identify areas in the field of mathematics teachers' use of technology which need more attention.

7.2 Literature Review

The integration of technology in teaching and learning is not intended to replace traditional methods, but to support schools to improve teaching and learning (Tishkovskaya & Lancaster, 2012). Some technology tools include 'power points, web-based games, the internet, projectors, smart boards, Elmos, calculators, videos, DVDs and music' (Moore, 2012).

The (GAISE College Report, 2010 ; 2016, p. 21) includes 'graphical calculators, statistical software packages, educational software, applets, spreadsheets, classroom response systems, web-based statistics related resources, data repositories, online texts, and data analysis routines in their list of recommended technology tools. ICTs, especially computers and internet technologies, support new ways of teaching and learning rather than simply allowing teachers and students to do what they have done before in a better way (Noor-UI-Amin, 2013). However, for teaching and learning to improve, technologies must be used as cognitive tools for learning and not simply as an alternative delivery platform (Herrington, Reeves, & Oliver, 2010). Moore (2012, p. 14) reports that integrating technology in a mathematics classroom can promote the development of computational skills, while also developing higher order mathematical skills. The view of Forster (2006) is that using technological tools can improve the learning of mathematics by allowing learners to pay attention to underlying properties and relationships instead of focusing on tedious complicated calculations that may sometimes detract from the intended outcomes. ICT provides opportunities for learning by helping learners to access, spread, renovate and share ideas and information, which is transmitted in integrated communication styles and designs.

Technological tools can also open up access to a wider variety of problem-solving strategies than those limited to paper and pencil strategies (Bansilal, 2015). Tools such as online videos allowed the students to vary the pace at which they could learn new material in mathematics (Bansilal, 2015). By providing access to different representations which help visualisation of mathematical objects, certain mathematics software can contribute to a deeper understanding of the concept. Technology also opens up possibilities for developing statistical concepts by enabling the visualisation of the concepts (Sorto & Lesser, 2009); it can make the demonstration of complex abstract ideas easier while also providing multiple examples (Chance, Ben-Zvi, Garfield, & Medina, 2007). In teaching statistics, technology can aid students in

learning to think statistically by facilitating access to real (and often large) datasets and fostering active learning. Thus it can allow a learner to explore concepts and analyse data, manage and visualise data, perform inference, and check conditions that underlie inference procedures (GAISE College Report, 2016).

Purcell, Heaps, Buchanan, and Friedrich (2013) describe the importance of internet and digital tools in teachers' work of teaching. They state that 'the greatest impact of the internet and other digital tools on their role as teachers has been access to more content and material for use in the classroom and a greater ability to keep up with developments in their field' (p. 51). Noor-Ul-Amin (2013) argues that networked computers with internet connectivity can increase learner motivation as it combines the media richness and interactivity of other ICTs with the opportunity to connect with real people and to participate in real world events. Kramarski and Feldman (2000) reported that instruction that integrates the use of the internet in classrooms improves learners' motivation in learning and has positive effects on learners' reading comprehension. Brändström (2011) examined the influence of the use of the internet on planning and instruction by interviewing five upper secondary school teachers. The findings revealed that the teachers consider the internet as a valuable source of information and an important additional teaching tool. It also reduces teachers' work while facilitating quick exchanges (Higgins, 2003).

Some studies have reported that the use of technology also increases teachers' confidence in the content (Brändström, 2011; Buabeng-Andoh, 2012; Cassim, 2010; Cox, Cox, & Preston, 2000; Leendertz, Bignaut, Nieuwoudt, Els, & Ellis, 2013; Mumtaz, 2000; O'Dwyer et al., 2003; Remesh, 2013; Sabzian & Gilakjani, 2013; Yang, 2013) . For instance, in Cox et al.'s (1999) study, teachers reported that using ICT increased their confidence. O'Dwyer et al. (2003) further found that higher teacher confidence is associated with the largest increased use for delivering instruction and, in particular, increased use for class preparation. Further findings showed a significant relationship between teachers' confidence and ICT applications (Albion, Jamieson-Proctor, & Finger, 2011; Tasir, Abour, Halim, & Harun, 2012).

Research conducted in South Africa reports that the use of computers tends to feature fairly extensively in the learning areas of Language and Mathematics, Natural Sciences and Technology, and less in Humanities and Arts (Lundall & Howell, 2000).

On the one hand, they found that in Grades 1 to 7 computers tend to be used mainly for drill and practice and problem-solving exercises; on the other hand, from Grade 8 upwards computers tend to be used for a greater variety of purposes in the teaching and learning process. They also mention that drill and practice exercises, although less prominent, continue to be used in Grades 8 to 12.

Leendertz et al. (2013) investigated the level of 'Technological Pedagogical Content Knowledge (TPACK) of mathematics teachers and how TPACK contributes towards more effective Grade 8 mathematics teaching in South African schools'. Their findings indicate that, with the improvement of TPACK of mathematics teachers, their confidence increases in their ability to apply technology for teaching mathematics in South African schools. Teachers acknowledged that ICT promotes conversations with colleagues and peers regarding teaching and learning practices and gives a platform to express their teaching and learning accomplishments. ICT also enabled them to conduct their administrative work more efficiently, allowed them to facilitate interactive lessons, and promoted confidence in using a variety of teaching and learning strategies designed for teaching (Leendertz et al., 2013).

Sometimes the failure by teachers to integrate technology in their classrooms is because of problems that are beyond their control (Marwan, 2008; Mumtaz, 2000). Some challenges experienced by teachers when trying to implement ICT include insufficient ability of ICT specialist teachers to teach students computer skills, lack of computer accessibility, lack of time as well as lack of financial support (Mumtaz, 2000). Similarly, Buabeng-Andoh (2012) identified poor ICT skills, low teacher confidence, insufficient pedagogical teacher training, absence of suitable educational software, limited access to ICT, inflexible structure of traditional education systems as well as limiting curricula design as some of the reasons which inhibited take-up of technology by teachers. The application of technology in teaching can lead to complexity because of the demands of learning newer technologies (Koehler & Mishra, 2009). Cavanagh, Reynolds, and Romanoski (2006) examined how the ICT learning culture reconciles student learning and curriculum implementation in the classroom. In their study, they found that students expressed high confidence in their capacity to use ICT in their learning, but teachers were uncertain about the extent to which the learning was sustained by the learners.

Teachers' beliefs about teaching and learning play a major role in their decisions about how to teach the content. Hollingsworth (1989) and Barkatsas and Malone (2005) articulated that the way teachers implement new methods or programmes in their classrooms relates to whether teachers' beliefs correspond with the suggested new methods. Ernest (1989) emphasises the important role of teachers' beliefs, particularly in mathematics education, where these beliefs depend on individual teachers. Ernest argues that teachers have particular beliefs about the nature of mathematics and how it is best taught. For instance, beliefs that mathematics is computation stems from ideas about the nature of mathematics whereas beliefs that teaching mathematics should be shaped by alternatives ideas stems from beliefs about teaching mathematics. Beswick et al. (2012) found that while some teachers agreed that mathematics is the same as computations and that telling learners the answer is an efficient way of facilitating their mathematics learning, other teachers of mathematics should be involved with learners' thinking. Beswick et al. (2012) are of the view that teacher's beliefs about general principles related to the nature of mathematics, and the learning and teaching of mathematics (rather than the use of specific approaches) are what matter to student learning.

Several studies have focused on teachers' beliefs towards technology (Cavas et al., 2009; Choi, 1992; Mueller, Wood, Willoughby, Ross, & Specht, 2008; O'Dwyer, Russell, & Bebell, 2005) as a factor which motivates teachers' use of technology. Some studies found a significant relationship between teachers' beliefs towards technology and their instructional technology practices (Ali, 2015; Mumtaz, 2000; Palak & Walls, 2009).

Further factors that have been explored with respect to teachers' use of ICT are that of gender and age. The findings of Choi (1992) revealed that females and young teachers hold a slightly higher computer literacy level than male teachers and older teachers respectively. However, the older age group tended to have more positive attitudes toward the instructional use of microcomputers in comparison with the younger age groups. However, the results of the study indicated no relationship between the teachers' attitudes and their knowledge of microcomputers. On the other hand, Almekhlafi and Almeqdadi (2010) found that male teachers were more likely to use technology than female teachers. Gender and age were also discussed by Cavas et al. (2009) who found that Turkish science teachers' attitudes towards ICT did not differ regarding gender, but differed regarding age, computer ownership at home and

computer experience. These authors state that factors influencing the use of technology include availability of computers in the classroom, sharing of resources, a supportive administration, strong support staff, environmental, personal, social and curricular issues. Similar findings indicated that school factors, personal factors as well as beliefs towards technology, influence teachers' use of technology (Cubukcuoglu, 2013; Mumtaz, 2000). Mumtaz (2000) identified an important technical sustenance of twenty hours per week that was necessary for teachers and found that a positive attitude of the principal contributed to teachers' use of technology. These authors agree it is important to support teachers in using technology in teaching and learning.

Sabzian and Gilakjani (2013) identified two contributing factors to teachers' low self-confidence in using technology. The authors found that limited computer instruction could lead to teachers' low confidence level when they initiate computer activities and result in high anxiety about using computers. The second was poor motivation which could result in insufficient knowledge in using instructional technology even if computers are provided in the classroom for teaching and learning. Ali (2015) points out that teachers' poor knowledge in using technology may be due to a lack of professional training towards computers and lack of teacher-centred experiences in education and the lack of technological devices. These studies emphasise the need for programmes that can provide effective computer instruction to teachers while also helping them gain experience in the use of the technological tools.

Using factor analysis, Leendertz, Blignaut, Ellis, and Nieuwoudt (2015) validated a questionnaire for ICT development of mathematics teachers. They found that the first factor was related to 'teachers' expectation' (reliability of 0.92), which means that mathematics teachers expect the DBE, provincial departments and schools, to work together to improve an ICT strategic plan in order to increase technology use. Based on their study, they emphasise that professional development courses are urgently needed to support teachers in integrating ICT into teaching and learning. The site of the training does not have to be confined to the school as Lundall and Howell (2000) point out that many schools indicated that some teachers have access to technology-related professional training opportunities that take place outside the school.

This study addresses the use of technology in teaching mathematics in KZN schools. As illustrated by the literature, recent advances in technology have unlocked entirely new directions for education research and I briefly surveyed some of the more pertinent studies in this area. I first looked at the ways in which digital classrooms support students' learning, before moving to the use of particular tools for instruction such as the internet which is a focus of this study. I then reviewed studies which investigated the association between using technology and particular demographic factors. The literature review also included studies about challenges faced by teachers in trying to take up the use of ICT in their classrooms. This review serves as a useful foundation to look at the use of technology by a group of KZN mathematics teachers, and to the associated factors which are associated with it.

7.3 Results and discussion

I start by exploring the extent to which the teachers have access to calculators, computers and internet in teaching mathematics, followed by details about the instructional purposes for which the technology is used. Thereafter I report in more detail on the differences in confidence and beliefs of teachers who use the internet for instructional purposes, and those who do not. This section is organised according to the research questions of the study.

7.3.1 To what extent do KwaZulu-Natal mathematics teachers use technology in their teaching practices?

Access to technology

Table 7.1 displays the results regarding the use of calculators and computers. Of the 75 teachers who were surveyed, only 49 (65%) teachers reported that in the schools where they were teaching, calculators were used to teach and learn mathematics and statistics, even though, calculators were commonly available. When asked about access to computers, there were even fewer teachers who enjoyed this privilege. There were only 33 (44%) teachers who reported that computers were available in the schools where they teach, and of this number, only 21(28%) said that computers were used to teach mathematics and statistics. Twenty (26.7%) had access to the internet and 19 (25.3%) said that computers were used for educational instruction.

Reports about the availability of computers at schools suggest similar figures to those reported by the teachers in this study. In 2015, 33.2% of schools had computers (South Africa Institute of Race Relations, 2015). Even though, in the current study, the availability of computers in schools was reported at approximately 44%, only 28.5% of the teachers reported that these were used for teaching mathematics and statistics which represents a limited use of technology.

Table 7. 1 Access to technology

Question	No	Yes
	Frequency (%)	Frequency (%)
Are calculators available in your school?	26 (34.7)	49 (65.3)
Do you use calculators for teaching mathematics or statistics	26 (34.7)	49 (65.3)
Are computers available?	42 (56.0)	33 (44.0)
Do you use them for teaching mathematics and statistics	54 (72.0)	21(28.0)
Do any of the computers learners use have access to the internet?	55 (73.3)	20 (26.7)
Do you use the internet for educational instructional purposes?	56 (74.7)	19 (25.3)

The use of computers and calculators in teaching mathematics and statistics was disaggregated by the grade in which teachers were teaching. Table 7.2 indicates that 84% teachers who were teaching Grades 10–12 mostly used calculators, compared to 36.7% teachers in Grades 4–9 who used them in teaching mathematics. On the other hand, only 40.0% teachers who were teaching in Grades 10–12 reported that they used computers in mathematics and statistics teaching and learning, whereas 10.0% teachers in Grades 4–9 reported that they used computers in the classroom.

Table 7. 2 The use of calculators and computers by grade.

Grades	Calculators		Computers	
	Yes (%)	No (%)	Yes (%)	No (%)
4-9	11(36.7)	19(63.3)	3(10.0)	27(90.0)
10-12	38(84.4)	7(15.6)	18(40.0)	27(60.0)

It is evident that in the schools represented in the study the use of computers in the classroom is still at the lowest level and much effort is needed to sensitise teachers to using computers for improved teaching of mathematics and statistics. This finding shows that the DoE (2007) recommendation that the use of ICT in the

classroom should aim to develop a range of skills ranging from basic ICT skills to developing specialisation and innovation in ICT education, is unlikely to be met under these conditions. It is clear that teachers would need much assistance and continuous professional teacher development on the implementation of information technology pedagogical knowledge in relation to integrating ICT in the teaching of mathematics (Cassim, 2010). Given that more than half the teachers do not have computers available at their schools, it is unrealistic to expect that these teachers would be able to take on the vision of the DOE in using ICT to improve the learning outcomes in the education system (DoBE, 2007).

The instructional purposes for which the technology is used.

Mishra and Koehler (2006) agree that the connection between technology and teaching can transform the conceptualization and the practice of teacher education, teacher training, and teachers' professional development. Teachers can use technology in different ways, such as in simple drill and practice tasks.

Drill-and-practice mathematics software offers teachers a relatively simple way to use technology in the classroom (Kuiper & de Pater-Sneep, 2014). Teachers could also use technology in more complex tasks such as using simulations in investigating real life data. Table 7.3 indicates how often technology (computers) is implemented in different teaching practices. It can be noted from Table 7.3 that most teachers reported that they never used technology for any of the instructional activities mentioned. It is clear that most of the teachers in the study group were not using technology at all, not even in the most rudimentary way. Activities such as collecting and retrieving data from computers are associated with exploring data in real-life applications. The use of statistics in understanding and making informed decisions in real life is an important outcome of the subject, and these findings show that teachers need more help in this regard.

Table 7. 3 Exploration of the use of technology in teachers' practice.

Teaching practice	Never	Rarely	Sometimes	Often
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Drill and practice	46(61.3)	7(9.3)	12(16.0)	10(13.4)
Demonstrate statistics principles	42(56.0)	9(12.0)	9(12.0)	15(20.0)
Collect data using sensors or probes (collecting data using software)	48(64.0)	13(17.3)	6(8.0)	8(11.7)
Retrieve or exchange data	47(62.7)	8(10.7)	12(16.0)	8(10.7)
Solve and compute statistical problems	46(61.3)	8(10.7)	10(13.3)	11(14.7)
Take a test or quiz	41(54.7)	8(10.7)	11(14.7)	15(20.0)

The use of the internet and teachers' confidence and beliefs

The data allowed us to look in more detail at the specific use of the internet for instructional purposes and to test whether this use was linked to certain factors. Ndlovu and Lawrence's (2012) view is that access to ICTs enables quality use for educational purposes. It is expected that a teacher who makes use of the internet as an additional teaching tool will most likely earn his/her students' respect and regard, which in turn may motivate teachers to develop more innovative ideas about teaching. Some studies contend that teachers with more access to the Web for instructional purposes had higher levels of self-determination and that teachers with better computer access had lower computer nervousness and more computer self-efficacy (Liu & Kleinsasser, 2015). Thus, accessibility to technology may be a factor which builds up teachers' knowledge.

I now investigate the links between the use of the internet and teachers' confidence and beliefs.

Teachers' confidence and the use of technology

Recent studies articulate that there exists a connection between teachers' confidence and the use of technology (Brändström, 2011; O'Dwyer et al., 2003; Sabzian & Gilakjani, 2013). Sabzian and Gilakjani (2013) argue that the lack of computer instruction often accounts for teachers' low confidence levels when they initiate computer activities. In this study, I explored whether teachers who use the internet for educational instruction purposes are confident in their ability to teach

mathematics. I considered topics such as percentage, fraction, decimal, inference and prediction, measurement, pattern and algebra, mental computation, pie graphs and histograms, range and variations, ideas of sampling and data collection, etc.

The results showed a statistically significant relationship between using the internet for educational instructional purposes and teachers' confidence in teaching mathematics or statistics topics. It can be noted from Table 4 that teachers who use the internet for instructional purposes expressed a high confidence in teaching percentages ($\chi^2 = 6.082(2)$, effect size=0.285, p-value=0.048), ratios and proportions ($\chi^2 = 9.835(2)$, effect size=0.362, p-value=0.007), pie charts and histograms ($\chi^2 = 12.231(2)$, effect size=0.285, p-value=0.048), pattern and algebra ($\chi^2 = 13.747(2)$, effect size=0.428, p-value=0.001), measurement ($\chi^2 = 6.399(2)$, effect size=0.292, p-value=0.041) and mental computation ($\chi^2 = 8.573(2)$, effect size=0.338, p-value=0.014).

The effect sizes reported in Table 7.4 and Table 7.5 indicate the mean difference between groups in standard score form, i.e. the quotient of the difference between the means to the standard deviation (Yu, 2001). In other words, they designate the standardized mean difference, or the response ratio. Effect size emphasises the size of the difference rather than confusing this with sample size (Coe, 2002). The values of effect sizes in Table 7.4 and Table 7.5 ranged between 0.2 and under 0.4 which indicate moderate practical significance (Becker, 2000; Cohen, 1988; Kotrlik & Williams, 2003).

Table 7. 4 Using internet for instructional purposes and teachers' confidence.

Topics Teachers'	Confidence	Using internet for instructional purposes				
		No	Yes	$\chi^2(df)$	p-value	Effect size
Percentages	Low	7(12.5)	1(5.3)	6.082 (2)	0.048	0.285
	Moderate	16(28.6)	1(5.3)			
	High	33(58.9)	17(89.5)			
Ratios and proportions	Low	11(19.6)	0(0.0)	9.835(2)	0.007	0.362
	Moderate	23(41.1)	4(21.1)			
	High	22(39.3)	15(78.9)			
Pie graphs and histograms	Low	11(19.6)	1(5.3)	12.231 (2)	0.002	0.320
	Moderate	17(30.4)	0(0.0)			
	High	28(50.0)	18(94.7)			
	Low	11(19,6)	0(0,0)	13.747(2)	0.001	0.428

Topics Teachers'	Confidence	Using internet for instructional purposes				
		No	Yes	X ² (df)	p-value	Effect size
Pattern and algebra	Moderate	19(33,9)	1(5,3)			
	High	26(46,4)	18(94,7)			
Measurement (Length, area, volume and time)	Low	9(16,1)	0(0,0)	6,399(2)	0.041	0.292
	Moderate	20(35,7)	4(21,1)			
	High	27(48,2)	15(78,9)			
Mental computation	Low	14(25,0)	2(10,5)	8,573(2)	0.014	0.338
	Moderate	25(44,6)	4(21,1)			
	High	17(30,4)	13(68,4)			

Teachers' beliefs about the goals of teaching mathematics

I further examined whether there is a significant relationship between using the internet for educational instructional purposes and teachers' beliefs about the nature of mathematics. It can be noted from Table 7.5 that teachers who reported that they use the internet, were more likely to agree about some broad goals of teaching mathematics (as identified by Beswick et al., 2012) than those who did not. Teachers who reported that they use the internet, agree that mathematics teaching should assist learners to develop an attitude of inquiry (asking questions, being curious about solutions) ($\chi^2 = 6.362(2)$, effect size=0.291, p-value=0.042), statistics teaching should assist learners to develop a positive attitude to problem solving as well as beliefs that statistical literacy ($\chi^2 = 6.050(2)$, effect size=0.284, p-value=0.049), thinking and reasoning are the main goals in statistical teaching and learning ($\chi^2 = 7.458(2)$, effect size=0.315, p-value=0.024), than those who do not use it. The findings from Table 7.5 further show that the use of the internet for educational instructional purposes is associated with a stronger belief in the value of linking teaching to other key areas ($\chi^2 = 11.797(2)$, effect size=0.404, p-value=0.003) as well as the need for applying statistics in real life settings out of the classroom situation ($\chi^2 = 8.701(2)$, effect size=0.397, p-value=0.013).

Table 7. 5 Using internet for education instructional purpose and teachers' beliefs about teaching mathematics

Teachers beliefs about goals		Using internet for educational instructional purpose				
		No	Yes	X ² (df)	P-value	Effect size
Mathematics teaching should assist learners to develop an attitude of inquiry (asking questions, being curious about solutions)	Disagree	1(1.8)	0(0.0)	6.362 (2)	0.042	0.291
	Neutral	14(25.0)	0(0.0)			
	Agree	41(73.2)	19(100.0)			
Statistical literacy, thinking and reasoning are the main goals in statistical teaching and learning	Disagree	1(1.8)	0(0.0)	7.458 (2)	0.024	0.315
	Neutral	16(28.6)	0(0.0)			
	Agree	39(69.6)	19(100.0)			
Goals of mathematics						
Connecting mathematics to other key learning areas	Low	20(35.7)	1(5.3)	11.79 (2)	0.003	0.404
	Moderate	21(37.5)	5(26.3)			
	High	15(26.8)	13(68.4)			
Using statistics in out of the classroom situations	Low	17(30.4)	2(10.5)	8.701 (2)	0.013	0.397
	Moderate	22(39.3)	4(21.1)			
	High	17(30.4)	13(68.4)			

7.3.2 To what extent are teachers positive about using technology in the teaching of mathematics?

Table 7.6 indicates that 60 (80%) of the 75 teachers in the study had a positive view regarding the use of technology to facilitate teaching and learning mathematics and statistics topics and 49 (65.3%) expressed a positive belief that it improves learners' understanding.

Table 7. 6 Teachers' beliefs about using technology in teaching and learning.

Teachers' beliefs	Disagree	Neutral	Agree	Total
Using technology to assess mathematics learning	3(4%)	12(16%)	60(80%)	75(100%)
Using technology helps with increasing learners' learning and understanding of statistics	11(14.7%)	15(20%)	49(65.3%)	75(100%)

I further used a comparison of means to identify factors which may be associated with teachers' positive beliefs towards technology. It can be noted from Table 7.7 that teachers aged ≤ 40 were more confident about the potential of technology to influence learning and understanding of statistics positively, than was the case for teachers who were aged >40 ($F=4.912$, $p\text{-value}=.030$, $\text{effect size}=0.251$) and that using technology helps with increasing learners' learning and understanding

of statistics ($F=8.886$, $p\text{-value}=0.004$, effect size $=0.329$). Thus, younger teachers were more positive towards the use of technology to enhance understanding of statistics than older teachers. These young teachers are the same group that have ≤ 10 years of teaching experience and it will be shown that they are the group who are more likely to make use of technology in the classroom.

Table 7. 7 Teachers' beliefs towards technology and effect of demographic factors.

Teachers' beliefs towards technology	Factors	Sum of Squares	Mean Square	F	Sig.	Effect size
Using technology to assess mathematics learning	Age group	2,569	2,569	4,912	0.030	0.251
	Using curriculum	3,641	3,641	7,164	0.009	0.299
	Professional learning	5,141	5,141	10,541	0.002	0.355
Using technology helps with increasing learners' learning and understanding of statistics	Age group	2,136	2,136	8,886	0.004	0.329
	Using curriculum	1,260	1,260	4,995	0.028	0.253
	Professional learning	1,102	1,102	4,328	0.041	0.237

These results support the findings of (Cavas et al., 2009), who reflected on science teachers' attitudes towards the use of technology in education. They found that the attitudes of young science teachers in their study (age group: 20–35) were more positive towards using technology in the classroom, which was significantly different from teachers in other age groups (36–49/50+). However, in another study, Choi (1992) found that older teachers displayed more positive attitudes towards computer use in education than was the case for the younger teachers in that study.

The findings further demonstrated that teachers who use the NCS in their teaching have positive beliefs that technology influences learning and understanding of statistics 40 ($F=7.164$, $p\text{-value}=0.009$, effect size $=0.299$) and that using technology helps to increase learners' learning and understanding of statistics ($F=4.995$, $p\text{-value}=0.028$, effect size $=0.253$). This indicates the importance of consulting curriculum as the factor which encourages teachers to use technology in teaching process.

Teachers largely agreed that the use of technology helps learners to develop their understanding of mathematics and statistics topics. Forty-nine out of 75 (65.3%) teachers said they believed that they would integrate technology into teaching and learning mathematics and statistics in the classroom.

Furthermore, the findings indicate that teachers who reported that they meet with a local group of teachers and discuss mathematics and statistics teaching on a regular

basic as a part of their professional learning, expressed positive beliefs that technology enhances learners' understanding ($F=10.541$, $p\text{-value}=0.002$, effect size= 0.355) and that using technology helps to increase learners' learning and understanding of statistics ($F=4.328$, $p\text{-value}=0.041$, effect size= 0.237) This finding indicates that in professional learning, teachers continue to acquire new skills while collaborating with other teachers and can share the best practice and integrate the innovations in the classroom. The DoBE (2007) supports this idea that teachers' desires and benefits should be the driving force for their professional growth.

7.3.3 Is there any relationship between demographic factors and the use of technology in instructional practices?

Technology knowledge, as other aspects of teacher knowledge, is not constant. It develops over time according to teachers' professional development or training, teaching experience as well as teachers' attainment to a higher level of education, etc. The comparison of means (a standard test used to compare differences between means of two or more groups) was used to identify factors associated with teachers' tendency to integrate technology into their teaching practice as reported in Table 7.3. The teachers' demographic factors that were tested included school quintile, gender, age, teaching experiences, education level, workshops attendance, grade they teach and their level of education and the different instruction practices. The analysis reported in Table 7.8 was made by comparing the means at a significance level $\alpha =0.05$, between the variables which were explained in Table 7.3 and the demographic factors reported in Table 2.1.

The findings reveal that the difference between the means is statistically significant for the factors of gender, level of study, teaching experience, attending workshops and school quintile and their ability to integrate technology in different instructional practices at $\alpha =0.05$. Table 7.8 reports only significant effect $p\text{-values} <0.05$. It can also be noted from Table 7.8 that the effect sizes from 0.2 and under 0.4 (**in bold**) indicate that the difference between groups in terms of using technology, has moderate practical significance. On the other hand, it can be noted from Table 7.8 that the effect sizes <0.2 , which indicates that the difference between groups in terms of using technology, has moderate practical significance (Kotrlik & Williams, 2003).

Table 7. 8 Factors associated with teachers' use of technology.

Factors	Teachers' practice	Mean Square	F	p-value	Effect size
Level of education	Drill and practice	29,501	32,686	0.000	0.309
	Demonstrate statistics principles	43,819	47,700	0.000	0.395
	Collect data using sensors or probes	19,069	24,034	0.000	0.248
	Retrieve or exchange data	26,244	31,960	0.000	0.304
	Solve and compute statistical problems	34,744	40,488	0.000	0.357
	Take a test or quiz	45,054	49,128	0.000	0.402
Quintile schools	Drill and practice	4.536	3.938	0.012	0.143
	Demonstrate statistics principles	8.384	6.944	0.000	0.227
	Collect data using sensors or probes	6.383	6.761	0.000	0.222
	Retrieve or exchange data	8.575	8.496	0.000	0.264
	Solve and compute statistical problems	3.681	2.588	0.060	0.099
	Take a test or quiz	25.818	21.869	0.000	0.231
Gender	Drill and practice	15.586	14.258	0.000	0.163
	Demonstrate statistics principles	22.461	18.544	0.000	0.203
	Collect data using sensors or probes	12.281	13.855	0.000	0.160
	Retrieve or exchange data	13.026	12.997	0.001	0.151
	Solve and compute statistical problems	15.586	13.909	0.000	0.160
	Take a test or quiz	25.818	21.869	0.000	0.231
Experience	Drill and practice	20.909	20.494	0.000	0.219
	Demonstrate statistics principles	21.780	17.844	0.000	0.196
	Collect data using sensors or probes	10.276	11.244	0.001	0.133
	Retrieve or exchange data	16.820	17.701	0.000	0.195
	Solve and compute statistical problems	13.176	11.421	0.001	0.135
	Take a test or quiz	12.500	9.171	0.003	0.112
Attended workshops	Drill and practice	7.738	6.445	0.013	0.081
	Demonstrate statistics principles	9.572	6.897	0.011	0.086
	Collect data using sensors or probes	4.485	4.516	0.037	0.058
	Retrieve or exchange data	7.848	7.313	0.009	0.091
	Solve and compute statistical problems	7.738	6.301	0.014	0.079
	Take a test or quiz	7.114	4.951	0.029	0.064

I also discuss the statistical relationship between some factors and the use of technology reported in Table 7.8 by examining which demographic group may be more likely to use technology in instructional practice than other group(s). Regression analysis was made using mean plots to compare the magnitude of each group in terms of using technology; however only those which reflected a moderate difference are reported. I found that teachers who hold postgraduate courses may be more likely to

use technology than teachers who have a bachelor's degree or below. It can be noted from Figure 7.1 that mean scores for teachers who attended postgraduate courses are greater in terms of taking a test or quiz, retrieving and exchange data and demonstrating statistical principal for those with bachelor's degrees in terms of using technology (e.g. 2.230 versus 1.340 and 2.350 versus 1.510). This result was similar to findings in a previous study that education level contributes to teachers' use of technology in instructional practices (Mathews & Guarino, 2000).

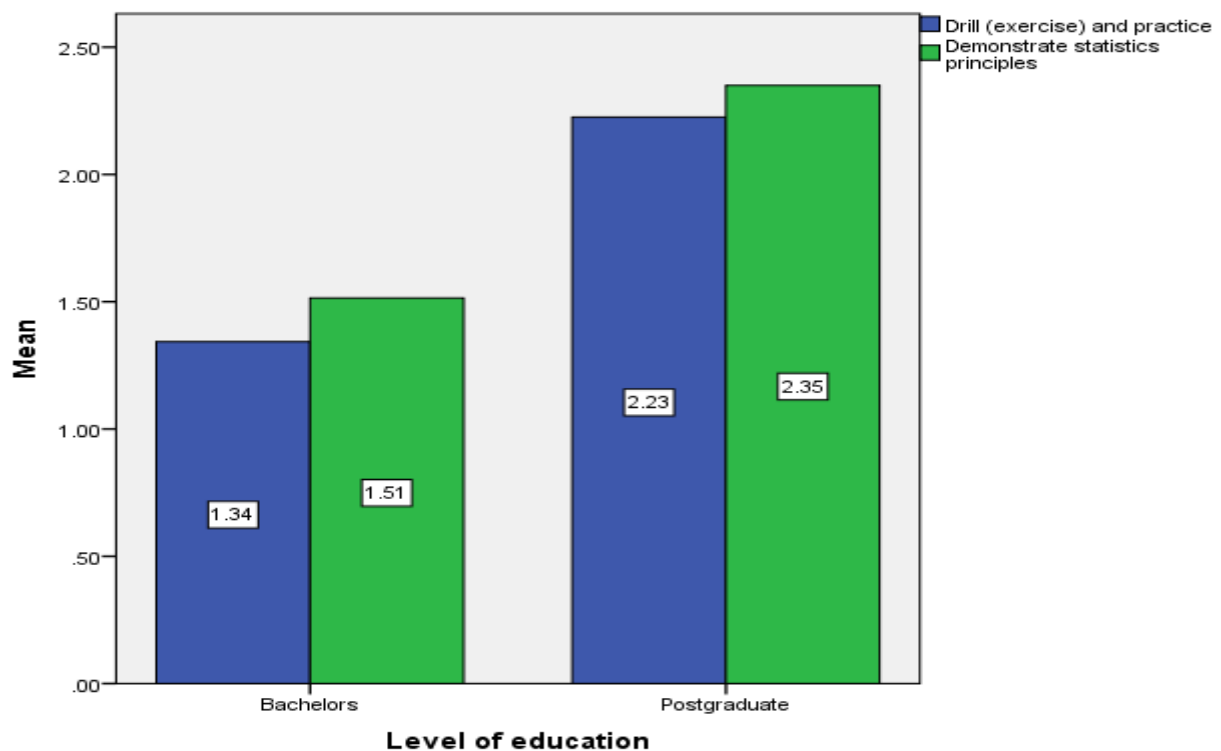


Figure 7.1 Using technology for instructional practice by level of education.

The Education Department introduced a funding policy by using a system of categorising schools into five quintiles in order to inform decisions around financial allocations. Quintile 1 schools are those serving the poorest children while Quintile 5 schools cater for children who come from well-resourced backgrounds. Looking at Table 7.8, there also appears to be a statistically significant difference between teachers' schools quintile and their ability to integrate technology in different instructional practices. It is observed from Figure 7.2 that teachers who teach in quintile 4 or 5 schools are more likely to use technology in instructional practices than teachers from the quintiles 1-3 schools. A general trend in the use of technology as the quintile ranking of the school increased can be noted from Figure 7.2; i.e. as the quintile ranking of the school increased, the use of technology in the various

instructional activities at that school increased. Thus, mean scores for teachers who teach in quintile four and up, are greater in terms of drilling and practice and demonstrating statistical principles than for those who teach in quintile one, two and three school in terms of using technology (e.g. 2.630 versus 1.690 or 1.570, 3.060 versus 1.750 or 1.570).

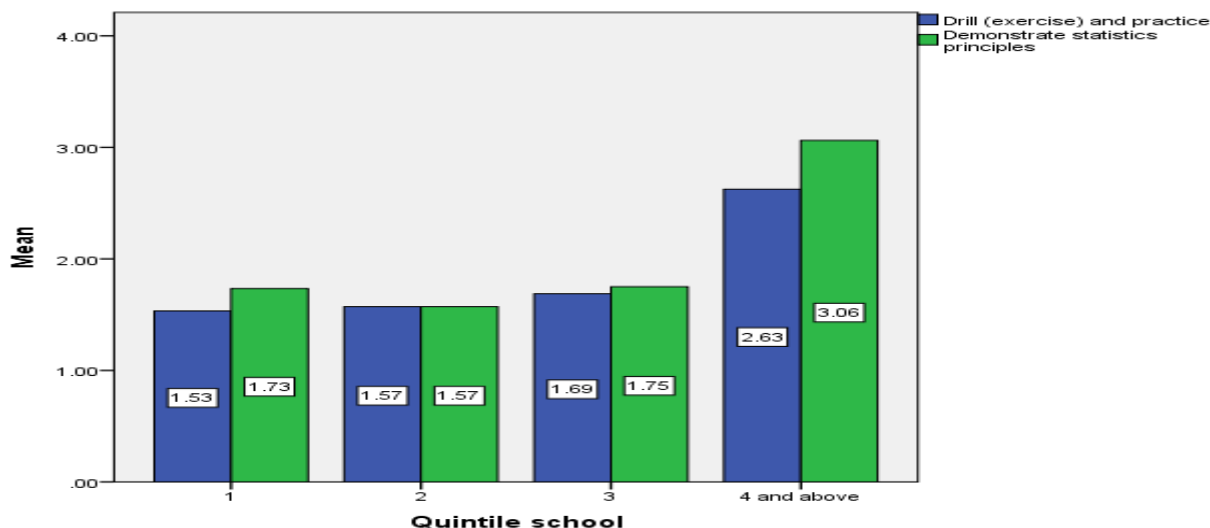


Figure 7.2 Using technology for instructional practice by school quintile.

It is evident, therefore, that teachers who teach in the poorest schools are using technology to a lesser extent than those in the more well-resourced schools, which illustrates the digital divide between the poorest and the richest schools. However, it is important to note that teachers need more than access to use technology; they also need support in using the technology to teach more effectively. Ndlovu and Lawrence (2012) point out that it is not simply the availability of technology that brings about improvements in learning, but the ways in which this technology is used. Many studies have also reported that poorly resourced schools have less access to ICT facilities than well-resourced schools (Ndlovu & Lawrence, 2012), and the results of the current study also support such findings.

The findings further showed that male teachers are more likely to integrate technology into their educational practice than female teachers, given that the mean scores of male teachers were higher than those of female teachers (e.g. 2.500 versus 1.405, .921 versus .165, etc.). This finding supports results from a study in Africa (Buabeng-Andoh, 2012, p. 39), which explored factors that influence 'teachers' adoption and integration of information and communication technology'. His finding

also showed that there was a significant difference between Ghanaian male and female teachers in technical ICT capabilities, where he found evidence that male teachers' scores were higher than those of female teachers in relation to the use of ICT in the classroom for instructional purposes.

Furthermore, it was noted that teachers whose teaching experience is ≤ 10 years, were more likely to use technology than the teachers with between > 10 years (e.g. 2.180 versus 1.250, 2.330 versus 1.400, etc.). This finding was also reported in another study (Almekhlafi & Almeqdadi, 2010) i.e. that novice teachers are more likely to use technology and the internet in several teaching practices, which may be because they grew up in the technological era. A statistically significant difference was also apparent between using technology in instructional practice and professional learning. This means that teachers who attended mathematical workshops may be more likely to use technology than those who did not (e.g. 2.148 versus 1.357, 1.967 versus 1.143, etc.). However, the effect sizes (Table 7.8) are small for all instructional practice. This means that the difference in terms of using technology between those who attended workshops and those who did not is small in practice. However, it appeared that the effect sizes (Table 7.8) are small for all instructional practice. This means that the difference in terms of using technology between those who attended workshops and those who did not is small in practice. Mueller et al. (2008) found that attending professional development workshops influences teachers' use of technology. Perhaps workshops that focus on the use and application of technology in the teaching of mathematics specifically may prove to have a bigger influence on whether teachers opt to use technology or not. Mueller et al., (2008) noted that 'professional development' and the 'continuing support of good practice' play a valuable role in sustaining the use of ICT in the classroom.

Generally, the above findings suggest that teachers must put a strong focus on using technology. Teaching will not be effective if teachers still focus on a single approach. They need to understand that using technology (e.g. Internet) can be another way in proving a variety of methods and assessments to use in the classroom. Technology makes teaching very fast and improve teachers 'confidence. It is useful to use it in preparing lessons, designing learning activities, and conducting assessments

7.4 Conclusion

Digital classrooms to support students' learning has been the focus of research recently and this study reveals some of the challenges that schools in poorer communities in South Africa experience in this regard. Results from this study indicate that approximately only one quarter of teachers has access to ICT for teaching mathematics. The use of ICT is even lower in the earlier Grades 4-9, where only 10% of the teachers said they used it for teaching mathematics. Furthermore, the data showed that teachers are generally more comfortable with integrating calculators when teaching mathematics and statistics, as compared to using computers. This indicates that teachers may need training in the integration of computers into teaching of mathematics and statistics in the classroom. Even though the practice of integrating technology into teaching instruction was not well-developed among these teachers, they exhibited a positive view with respect to teaching using technology. Of interest is the finding that teachers who reported that they use the internet for instructional purposes held more positive views about the broad goals of mathematics and were also more confident about teaching mathematics than those teachers who did not. Beswick et al. (2012) assert that it is teachers' beliefs about general principles about the learning and teaching of mathematics that make a difference to student learning.

This study suggests that teachers who have access to internet resources have progressive views about what the goals of mathematics and statistics should be. They also have stronger beliefs about the role of real life applications in learning statistics and the need for connections across various subjects. The study also found that teachers who use the internet have higher levels of confidence in teaching mathematics. This may be because teachers who have access to a wider set of resources have a greater chance of learning more about the broad goals and applicability of mathematics beyond the confines of the classroom. Knowing more about the connections between mathematics and the real world helps people to better understand the role of fundamental concepts such as percentages etc. and this may in turn improve their confidence about teaching these concepts.

A problem that has been exposed is that although some schools are reported to have computers, these computers are not used in instructional practice, but are used for administrative purposes. It is not clear whether this is because teachers do

not have the necessary skills, are reluctant to use the computers, or whether it is because school management is restricting the teachers' access to the technology. If computers are available but are not being used, the possible reasons for this state of affairs need to be urgently probed. Interventions which seek to increase access to technology will not be successful if the roll-out of computers does not result in a concomitant increase in the teachers' use of the technology. This study has provided evidence that teachers who attend workshops are more likely to use technology in their instructional practices than those who do not; hence, interventions which aim to increase the use of ICT in schools must be accompanied by continuous support. It is the support through workshops that will enable teachers to develop confidence in using technology and it may lead to more progressive attitudes by school management regarding the use of computers in classrooms. An important finding of the study is that teachers display different levels of technological readiness and enthusiasm according to their age, experience, gender and how well resourced their school is. Older teachers appear to need more support to help them become more confident to take on the technology.

Younger teachers are more confident and will not need as much support as their older counterparts. In addition, the study has also provided further evidence of the digital divide between schools with different quintile rankings. The digital divide presents a barrier to achieving equity in the provision of quality education to all learners. The removal of the digital divide requires more than just resources because it is the way in which the resources are used that makes the difference in the quality of the learning experience that is offered. The study shows that teachers from Quintile 1 schools need much more sustained attention and support, different in form and substance than those from Quintile four and above.

Successful integration of technology can have a transformative effect on schools and the education system as a whole. The study shows that teachers who have made a start towards using the internet for their teaching, have also developed broader understandings about the value and aim of teaching mathematics. Hence, helping teachers to take on technological resources is likely to assist them to develop new pedagogies that can help learners engage productively with the content of the subject. Continuous professional development will be required to help teachers integrate the newly acquired technological knowledge into their pedagogical

knowledge so that they can develop in all the components specified in Mishra and Koehler's (2006) TPCK framework. In order for the Department of Basic Education to realise their vision of helping their learners to function effectively in a knowledge society by using appropriate ICT in their schools (DoE, 2007), teachers would need sustained support and assistance to develop the necessary ICT capabilities. Any intervention which involves provision of technological resources such as internet access, mobile tablets or laptops will need to be accompanied by the relevant teacher professional development training courses, as well as training and sustained support for using and maintaining the infrastructure. In the next chapter, I examine mathematics teachers' level of proportional reasoning in solving proportional tasks.

CHAPTER VIII. EXAMINING TEACHERS' PROPORTIONAL REASONING IN SOLVING PROPORTIONS TASKS

8.1 Introduction

Proportional reasoning (PR) is an important component of numeracy which emerges as a key competence in middle years of schooling. Proportional situation problems involve situations in which the mathematical relationships are multiplicative in nature (Beswick, 2008a; Hilton, Hilton, Dole, & Goos, 2013). Hence in proportional situations, multiplicative reasoning takes precedence over additive reasoning and change is seen in a relative instead of an absolute sense. It plays a fundamental role in solving real-world problems because it requires an understanding and interpretation of situations that necessitates comparison in relative terms (Dole, Hilton, & Hilton, 2015). In addition, it is believed to be vital for problem-solving and reasoning, which are key cognitive domains of mathematics teaching and learning (Chaim, Keret, & Ilany, 2012). It is mostly used in calculation activities and domains based on the notion of scale, probability, percent, rate, trigonometry, equivalence, and measurement, which are routinely used in our everyday situations and work places.

Dole et al. (2015) emphasize that people with strong proportional reasoning in all school subject areas, including mathematics, will have the potential of developing essential life skills as well as in numeracy improvement. Trauth (2006) denotes that "proportional reasoning plays an important contributor in both standardized measures of aptitude and for staying in mathematics" (p.979). Therefore, it is very important for learners to be familiar with and to spend time solving problems involving proportional reasoning in order to improve their mathematical skills.

Teachers play a vital role in helping their students understand mathematics. Concepts which contribute to the development of proportional reasoning include fractions, ratios, and percent and it is essential that teachers mediate these concepts so that their learners can develop a robust understanding of these important foundational mathematics ideas. Hence it is important for teachers to understand these concepts and to be able to solve problems themselves. In this study we explore teachers' proportional reasoning skills as evidenced in their responses to four tasks. I then explore whether teachers' demographic factors such as gender, teaching experience, using curriculum and attending mathematics workshops, appear to

influence their proportional reasoning skills. Finally, I investigate whether teachers' confidence about their personal mathematical literacy skills as well as their confidence in teaching related topics, is linked to their proportional reasoning skills.

8.2 Literature Review

Proportional reasoning involves the understanding of proportionality in the relationship between two quantities. It uses multiplication and division to compare quantities and to describe how these quantities relate to each other (Beswick, 2008a; Lo, 2004). It is usually first encountered in relation to fractions, in which the numerator and denominator express a relationship between two quantities as well as together representing a discrete number (Beswick, 2008a, p. 1). Fractions also represent two or more numbers in which the top number (numerator) illustrates a part that is related to the whole unit, which is represented by the bottom number (denominator). Ratios represent the relationship between two numbers indicating how many times the first number contains the second ($a:b$) or $\frac{a}{b}$ whereas a proportion symbolizes a statement that two ratios or two fractions are equal (e.g. $\frac{a}{b} = \frac{c}{d}$ or $a:b = c:d$). Proportions refer to the equivalence of two such relational quantities (Beswick, 2008a), for example, when I want to find the number of sevenths equivalent to three quarters

($a:7 = 3:4$).

The learning of percentages involves setting up a proportion in words first (Kulm, 2008). Percentages are also mostly used to represent proportions in real life. Proportions are necessary in pie charts where they represent the quantities of each category reported in pie charts. Similarly, pie charts are generally used to show percentage or proportional data and usually the percentages are represented by each portion of pie. Pie charts are useful for displaying data for around six classes or fewer. When there are more categories it is difficult for the eye to differentiate between the relative sizes of the different sectors and so the chart becomes difficult to interpret.

In solving tasks based on proportions (as well as other mathematical domains) teachers need to have mathematical knowledge and skill unique to teaching which is referred to as specialized content knowledge (SCK) (Ball et al., 2008). According to Ball et al., SCK is the knowledge of mathematics which enables teachers to teach mathematical tasks. SCK enables teachers to accurately “represent mathematical

ideas, provide mathematical explanations for common rules and procedures, examine and understand unusual solution methods or problems” (p. 377). SCK includes the capability to demonstrate with detailed explanation, or to explain when and why a particular quantity, table, or graph would be more appropriate than another (Burgess, 2009). Other researchers support the idea of Ball et al. and Burgess by emphasising that SCK goes beyond common content knowledge because it includes extended knowledge (Pino-Fan, Godino, Font, & Castro, 2013). Khashan (2014) points out the role of both conceptual and procedural knowledge in solving mathematical tasks. On the one hand, this author describes conceptual knowledge as the elementary mathematics constructs and relations between the ideas that illustrate mathematical procedures, and give it meaning. It also includes the specific knowledge on the use of the concept of fractions including their use, language and problem solving as well as general knowledge on how they operate or are justified, including assessment processes (Olfos, Goldrine, & Estrella, 2014). On the other hand, procedural knowledge addresses the mastery of mathematical skills, acquaintance of the procedures to demonstrate the mathematical components, algorithms and definitions.

Fennema and Franke (1992) state that teacher knowledge is continually changing and developing, it grows through interactions with mathematical learning in the classroom environment, through engagement with learners, and through preservice professional experiences. Other studies support this view emphasising that content knowledge develops through teaching experience (Fumer & Bemian, 2003; Kleickmann et al., 2013; Rice, 2010), and teachers’ professional development (Hilton et al., 2013; Stols, Olivier, & Grayson, 2007; Worden, 2015).

It is further expected that proportional reasoning would enable teachers to develop confidence in teaching various mathematical subjects. *Confidence* means belief in oneself and one's powers or abilities to achieve something. In their study, Hilton et al. (2013) report that teachers who participated in workshops about proportional reasoning, felt confident that they were able to teach the algorithmic aspects of proportional reasoning and that they would be able to identify situations of proportion in the school surroundings. Cramer, Post, and Currier (1993) comment that “Having a better understanding of what proportional reasoning entails, should influence our classroom instruction” (p.2). However, it may happen that both students and teachers encounter misconceptions in solving or teaching proportional tasks.

8.1.1 Understanding misconceptions and errors

In solving mathematical problems, sometimes both teachers and learners commit various types of errors due to the misconceptions or misunderstanding of certain topics. A misconception describes a result of the lack of understanding which is, in many cases, characterised by misapplication of a rule or mathematical generalization (Spooner, 2012). Otero and Nathan (2008) comment that “the notion of misconceptions may be understood by preservice teachers to mean something that is wrong, bad, broken, and in need of being fixed” (p.22). Studies about teachers’ misconceptions have mostly addressed preservice teachers’ problems more particularly (Cakiroglu & Boone, 2002; Dollard, 2011; Graeber, Tirosh, & Glover, 1989; Olanoff, Lo, & Tobias, 2014; Otero & Nathan, 2008) where these teachers’ misconceptions may be because they lack teaching experience. Graeber et al. (1989) interviewed 129 female preservice teachers and explored their misconceptions in solving verbal problems in multiplication and division. The findings revealed that teachers held misconceptions that “the divisor must be a whole number” and that “multiplication always makes bigger and division always makes smaller”.

Moru, Qhobela, Wetsi, and Nchejane (2014), Olivier (2003) and Gardee (2015) describe misconceptions as the underlying conceptual structures that rise to errors and consequently, errors might be results of the presence of misconceptions. Research about teachers' misconceptions has informed teacher-education courses of the need to be aware of the influence of teachers' misconceptions upon students' knowledge constructions (Thipkong & Davis, 1991). In their research, they identified preservice teachers' misconceptions in interpreting and applying decimals, and they noticed that the misconception that "multiplication makes bigger, division makes smaller" was extremely predominant. They suggested that if teachers were aware of their own errors and misconceptions in particular in mathematical topics, such errors and misconceptions would not be transferred to learners. Sadler and Sonnert (2016) support this idea, mentioning that teachers’ misconceptions limit them in teaching important concepts.

In learning proportions, misconceptions may arise when one cannot understand the relationship between fractions, decimals, ratios and percentages (Barnett, 1994; Moss & Case, 1999). It is very important to know the connections between these concepts. An understanding of these concepts helps solve everyday life problems

that require calculations in various activities such as shopping, budgeting, diluting mixtures, interpreting real life information such as probabilities and odds, and converting metric units. In learning fractions, misconceptions can arise in partition of fractions. Partition consists of shaping an object into parts with equal sizes (Brijlall, Maharaj, & Molebale, 2011). In their study, these authors identify the misconceptions which appeared when students had to identify $\frac{1}{3}$ on the figure (the partitions were not equal). Misconceptions also arise when both teachers and learners compare the whole numbers in fraction situations, such that a fraction with a big denominator is larger (Lyons, 2010). For instance, when is $\frac{1}{6}$ > than $\frac{1}{2}$? When such misconceptions arise it is advisable to make reference to the whole.

In learning proportions for the case of percentages, most misconceptions appear when learners or teachers do not understand that percentages are a number out of one hundred or thinking that percent cannot be greater than 100. Every number expressed in percentage must be characterized by the symbol %, otherwise it would be a misconception. Thus, ignoring the sign % is misconception (Baratta, Price, Stacey, Steinle, & Gvozdenko, 2010), which violates the rules of writing percentages. Many pupils find it difficult to understand what a percentage actually *is* and then how to find a percentage of a quantity in a specific context, e.g. percentages means dividing: 20% of 200 is 200:20. This is misapplication of the rule of percentage. In calculating percentage, it is important to distinguish the meaning of x% of y and the percentage of $\frac{x}{y}$. E.g. 40% of 120 is equal to $\frac{40 \times 120}{100}$ while the percentage of $\frac{40}{120}$ is equal to $\frac{40 \times 100}{120}$.

In terms of interpreting pie chart, many teachers and learners do not understand the relationships embedded within a pie chart, that the percentages of different proportions which compose the pie chart must add up to 100% (George & Mallery, 2016; Lieu & Sorby, 2015). Others make mistakes when rounding up or down, which may lead to the violation of the total percentages distributed in the pie chart. Errors may also appear when constructing the pie chart by using negative values or putting too much information on it, which may confuse the reader. Pie charts are meaningless when they do not satisfy these rules.

8.1. 2 Research on proportional reasoning in South Africa

Although a lot of research has been conducted on students' understanding of proportional reasoning, very few publications actually focus on teachers' conceptual understanding of ratios and proportion in South Africa. Venkat and Spaul (2015) report that proportional reasoning is critical within middle years' in-service mathematics teacher education in South Africa, and there is an urgent need to improve mathematical knowledge for teaching algebra. In relation to teaching fractions, studies suggested that much effort must be made by teachers to seek and design effective strategies in order to help learners with the understanding of partitive and other meanings of fraction division (Brijlall et al., 2011). For instance their study suggests the use of practical work and real life examples which contributes to the improvement of learners' understanding of the fraction concept. In her study, Bansilal (2011) mentioned that some teachers demonstrated a weak conception of the basic mathematics concept of percentage in terms of inflation rate signifier, which prevented them from attaining a high level of understanding of percentage. The misconceptions which appeared in her study were that teachers add two percentage quantities by treating them as numbers instead of making sense of the whole.

Kazunga and Bansilal (2015) examined 101 teachers' understanding in relation to solving ratio and proportion tasks. Their results showed that only 60% of the participants were able to solve the problem correctly. Besides, research points out that South African teachers' knowledge of data handling is limited (North, Gal, et al., 2014; North & Scheiber, 2008; North, Zewotir, et al., 2014) and suggests that statistics education must be supported in order to prepare mathematics teachers to teach statistics included in the broadened curriculum (Wessels, 2008).

Further studies mentioned that many South African mathematics teachers have below basic levels of content knowledge, with high percentages of teachers being unable to answer the questions aimed at their pupils (Hofmeyr & Drape, 2000). Shepherd (2013) also highlights a lack of content knowledge especially in mathematics and sciences for South Africa teachers, which may be one factor of learners' underachievement. Venkat and Spaul (2015) further explored teachers' performance on mathematical tasks in South Africa schools in grade four, five and six. Their findings showed a significant gap on grade six, with the highest performance seen on the estimation/rounding task with 64% of grade 4 and 68% of grade 5 teachers

getting this item correct. They also found that only half of the teachers from both grades were able to answer the fraction, addition, time, and pattern continuation items correctly, with this facility dropping to below a third of teachers in both grades getting the perimeter item correct.

In relation to teaching statistics, studies point out incompetence of statistical knowledge in teaching statistical topics (Wessels & Nieuwoudt, 2010). North and Zewotir (2006) add that most teachers who teach in rural schools performed poorly on the items. Another study pointed out limited knowledge of data handling for South African mathematics teachers (Adu & Gosa, 2014), and suggested urgent professional development courses in developing statistical thinking for South Africa mathematics teachers (Wessels & Nieuwoudt, 2011). Based on these findings, I endeavour to add our contribution by studying teachers' proportional reasoning, especially how they approach and solve proportional tasks.

This study contributes to the previous studies by exploring teachers' proportional reasoning in solving two fraction tasks discussed in (Beswick, 2008a) and two percent tasks explored in (Beswick, 2008a, 2008b). These tasks were explored in Australia, and were adapted in KwaZulu-Natal in order to explore teachers' understanding towards them. As these teachers are supposed to teach proportions in the middle grades, I need to determine whether they have the necessary understanding of the proportional tasks. A unique contribution of this study is the exploration of factors which are associated with teachers' levels of proportional reasoning. In this study one of the focuses is on whether gender seems to play a role in the achievement of mathematics teachers on tasks involving proportional reasoning, an area in which there do not seem to be many results. Furthermore, I investigate the relationship between teachers' proportional reasoning and their confidence in their mathematical teaching skills and mathematical literacy skills, which have not been addressed by previous researchers.

Proportional tasks

Task 1. *Mary and John both receive pocket money. Mary spends $\frac{1}{4}$ of hers and John spends $\frac{1}{2}$ of his.*

A. Is it possible for Mary to have spent more than John?

B. Why do you think this? Explain your reasoning

Task 2. Consider the following problem that learners were asked in a survey about chance and data:

The following information is from a survey about smoking and lung disease among 250 people.

	Lung disease	No lung disease	Total
Smoking	90	60	150
No smoking	60	40	100
Total	150	100	250

A. Using this information, do you think that for this sample of people, lung disease is affected by smoking?

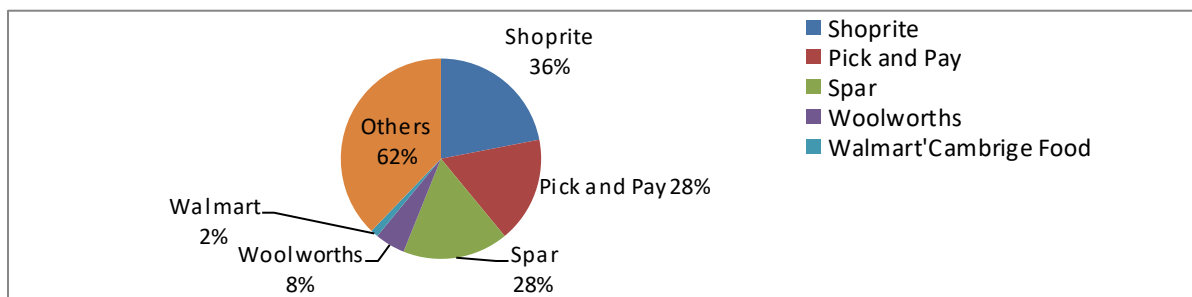
B. Explain your reasoning

Task 3. A. What is 90% of 40?

C. Explain your reasoning

Task 4. Teachers' knowledge about pie chart

National wide retail grocery market shares (demonstration, not factual)



A. Explain the meaning of this pie chart.

B. Is there anything unusual about it?

In order to respond to these research questions, the study implemented four proportional tasks (Beswick, 2008a, 2008b) carried out in Australia, in KwaZulu-Natal. Beswick (2008a) explored students' understanding in solving proportions tasks while Beswick (2008b) examined teachers' PCK in solving percent tasks (see task three and four). In this study, these tasks were investigated in a different context, to examine proportional reasoning skills of teachers from KZN. I also examined whether teachers'

demographic factors impacted on teachers' proportional reasoning development. Furthermore, I investigate whether there appears a connection between proportional reasoning and teachers' confidence in teaching a variety of mathematics and statistics topics as well and about using mathematics and statistics in everyday life. The responses were coded hierarchically according to their degree of appropriateness, such that the higher level of code corresponds to the correct answer.

8. 3 Results and discussion

The results are reported in three sections. I first describe the various responses given by the teachers to these proportional reasoning tasks. Thereafter, I consider whether there is any association between particular teacher demographic factors and the likelihood of displaying appropriate proportional reasoning skills. Finally, I explore the relationship between teachers' proportional reasoning skills, and their beliefs about, and skills of using mathematics in real life situations.

8.3.1 What do the teachers' written responses indicate about their proportional reasoning skills?

The teacher's written responses were broadly categorised into three main categories which are described below.

Blank or no engagement

Many teachers' responses did not show any engagement with the task and many teachers seem to have completely misunderstood some tasks. Statements like "not know, do not understand" show that no attempt has been made in solving the problem. Some responses show a disinclination to engage with substantial issues such as "Mary spent more than John, John spent more than Mary".

Partial answers

Partial answers using irrelevant justifications.

Some teachers showed limited engagement without addressing the use of proportions or percentages because they seemed have been side tracked by irrelevant information. Some responses indicated teachers' existing beliefs about the issue which mostly appeared in the task about smoking and LD, e.g. "LD is mostly affected by smoking". Others provided some irrelevant descriptions about how the graph looked (colours) or about missing shops e.g. "they are other shops that are not listed in the graph" for the problem of pie chart (colours, shops,) In this category, there was no reference to the use of proportions or percentages, e.g., 90% of 40 (third task) is 50,30,.. etc.

Partial answers using some proportional reasoning

Partial answers are those which use some aspects of proportions or percentages but which may not address the complete situation (Beswick, 2008a). In the Mary and John task, although the teachers showed signs of engagement with the relevant mathematical ideas, the critical notion that the relative sizes of fractions which is dependent upon the size of the whole, is missing. Teachers compare two fractions as if they are entities on their own, without making reference to the whole, e.g. "No, because Mary spends $\frac{1}{4} < \frac{1}{2}$ for John"; "Not possible, because $\frac{1}{4} < \frac{1}{2}$ " [without referring to the whole] (Lyons, 2010). Beswick (2008a) comments that such reasoning is possibly unsurprising given that many typical fraction exercises involve working on decontextualized problems in which there is unspecified assumption that the wholes to which the various relate are the same (Beswick, 2008a).

For the LD task, teachers engaged with the problem using a single comparison of just two ratios from the table. There is no evidence that these numbers were considered in relation to any of the other data. For example, teachers respond that LD is caused by smoking because $90/150$ is bigger than $60/150$ so therefore LD is caused by smoking (just referring to the totals in the first row). They may also argue using the numbers in the first column that since $3/5$ is larger than $2/5$, that smoking causes LD.

For the problem of finding 90% of 40, partial reasoning describes an incomplete approach of solving percentages or misapplication of the rules of percentages, e.g. 90% of 40 is $90 \times 40 = 3600$, 3600%; 36% (misunderstanding of the use of % symbol). For the problem of the pie chart, teachers mention that there is

something unusual but do not address the error, e.g. It is unusual that Walmart has small shares.

Appropriate reasoning

Teachers' responses in this category appropriate reasoning includes correct answers with a detailed approach and specific examples representing the procedure used to get the answer (Beswick, 2008a). In this category, the whole is addressed. For instance, one teacher said that it possible for Mary to spend more than John if she had more amount than John, e.g. if Mary had R100 and John had R20, then $\frac{1}{4}$ of 100 $> \frac{1}{2}$ of 20, and then Mary will spend more than John).

For the problem asking them to find 90% of 40, the appropriate answer is "36" because $90\% \text{ of } 40 = \frac{90}{100} \times 40 = \frac{3600}{100} = 36$. For the problem of smoking and lung disease, the appropriate answer is that smoking does not affect LD because looking at both sides, the proportions are the same. Teachers compare each cell for both the marginal totals, and do not look at only one row or column.

For the problem of the pie chart, teachers give an appropriate definition of the pie chart and address the error in the graph, e.g. this pie chart is about national grocery figures, however, the percentages do not add up to 100%. Other teachers immediately recognised the error in the graph and they mentioned that the graph would not be used, it is meaningless because the percentages of different portions are >100 ($62\% + 36\% + 28\% + 28\% + 8\% + 2\% = 164\% > 100\%$).

Table 8.1 presents a summary of these responses, with the results for each category described above in the four tasks. The findings show that while most teachers were able to provide an appropriate answer for task 3 (calculating 90% of 40), only ten teachers provided appropriate answers for the problem of smoking and LD. Also Table 8.1 indicates that approximately 50% of the teachers managed to make reference to the whole for the problem of Mary and John and responded appropriately to the pie chart problem. This finding was used to examine further issues; firstly, it was used to investigate whether the demographic factors appear to be related to teachers' levels of proportional reasoning. Secondly, I explain in the next section how I used these categories to generate an overall score of proportional reasoning skills, which is used in the quantitative analysis that follows.

Table 8. 1 Exploring teachers' proportional reasoning

Codes	Score	Task 1 (Mary and John)			Task 2 (smoking and LD)			Task 3 (what is 90% of 40)			Task 4 (pie chart)		
		%	Sub Category	Example(s)	%	Sub category	Examples		Subcategory	Examples	%	Subcategory	Examples
Incorrect answers	0	8 (10.6%)	No answer	Not know	22(29.3%)	No answer	Don't know	6(8%)	Not know	No answer	6(8%)	Not know	No answer
			Restating of question	She only spent a 1/4 and John spent 1/2"		Yes with incorrect reasoning	Yes, because smoking is dangerous in lungs, "We don't know how they collected their sample. It could be biased"		Incorrect Without explanation	900/4,9/4,96, 0.9,30/40,39, 30,39,33.2, 19,20		Irrelevant	Not addressing to the problem
			Response with no justification	Mary spent more than John						No with incorrect reasoning		No there is nothing unusual	
Partial answers	1	32(42.7%)	Displays understanding of 1/2 and 1/4 quantities only. Uses whole number reasoning	No, "Because 1/2 is more than 1/4". No attempt to integrate into the context.	43(57.4%)	No with irrelevant reasoning	No, because 60 people that don't smoke had lung cancer" No, because 90 people have lung disease by smoking	17(22.7%)	Use of %, but incorrectly	90x40=3600, 3600% 90x40=1260, 40+90%, = 130, 50= (90-40), ... ,10% of 40 is 4% x90=36%	35(46.7%)	Explained the meaning of the pie chart but have not identified the error in the graph	This pie chart represents the rate of market share nationwide, unusual is that others are bigger
			Same amount	No, If the amount is the same		Yes, may consider only one row or column	Yes, because all up 150 people get lung disease 90 of it is by smokers and only 60 of it is not by smoking.					Said yes that it has unusual, without reasoning.	Yes
Appropriate reasoning	2	35(46.7%)	Appropriate reasoning with specific examples, or pointing out that it depends on the amount	Yes, we do not know how much each had. It depends on the given amount. "M could have R10, and spends a 1/4 of it that leaves 2.5. R4 and spends 1/2 of it that leaves R2.	10(13.3%)	No, and demonstrate proportional reasoning	No, because both the smokers and non-smokers have 3/5 with lung disease (90/150 and 60/100) and 2/5 with no disease (60/100 and 40/100).	52(69.3%)	Correct answers	The answer is 36, because 90 of 40 = 90/100 x 40/1 = 36 take 90/100 multiply by 40 and get the answer, percentage is out 100	34(45.3%)	Has identified the meaning of the pie chart, said that there is something unusual on the pie chart and addressed the error	The pie chart shows which shops have a high or low market share; yes, unusual because the total % of different portions > 100.

8.3.2 Are there some demographic factors which appear to be associated with teachers' proportional reasoning skills?

In order to investigate whether there are any demographic factors associated with teachers' proportional reasoning skills, I looked at the response of the teachers across the four tasks. I assigned a score of 0, 1 or 2 respectively to each of the incorrect, partial and appropriate reasoning responses on each task. Those teachers who achieved a score of 2, were considered to be displaying a reasonable level of proportional reasoning skills, and those who achieved less than this are described as displaying low levels of proportional reasoning skills. This dichotomous variable was termed "overall proportional reasoning" and is reported in Table 8.2.

Table 8. 2 Teachers' overall score

Proportional reasoning status	Frequency	Percentage
Showing some understanding of proportional reasoning	42	56%
Appropriate reasoning	33	44%

Demographic Factors and proportional reasoning development

In order to assess the factors influencing proportional reasoning, binary logistic regression at a significance level of $\alpha = .05$ was used.

The omnibus tests of model coefficients table gives the result of the Likelihood Ratio (LR) test which indicates whether the inclusion of this block of variables teaching experience, gender, age group, level of education, attending workshop and using the curriculum, contributes significantly to model fit. Like the likelihood ratio test statistic, the omnibus test statistic is a measure of the overall model fit. It tests the hypothesis that:

H_0 : All the coefficients of independent variables are equal to zero.

H_1 : There is at least one coefficient of an independent variable that is not equal to zero.

Table 8.3 below shows the omnibus test of model coefficients based on chi-square test that implies that the overall model is predictive of proportional reasoning

(we are interested in row three “ Model”): (5 degrees of freedom) = 36.654, p-value < .000, and the null hypothesis can be rejected. Thus, our model defined in Table 8.3 can be used.

Table 8. 3 Omnibus test of model coefficient

		Chi-square	DF	P-value
Step 1	Step	36,654	5	0,000
	Block	36,654	5	0,000
	Model	36,654	5	0,000

DF= degree of freedom

Furthermore, Hosmer-Lemeshow (H-L) goodness-of-fit statistics (Hosmer & Lemeshow, 2000) was also used to assess the model fit. This test compares the predicted values against the actual values of the dependent variable. The method is similar to the chi-square goodness-of-fit. A very small chi-square of H-L test statistic is desirable and a p-value greater than 0.05 indicates that the model is acceptable (Hosmer & Lemeshow, 2000). The findings reflected in Table 8.4 indicate that the chi-square values of H-L test and non-significant p-values are greater than 0.05, which indicates the goodness of fit of the models.

Table 8. 4 Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	3,997	7	0,780

Where, Df = number of groups -2

Table 8.5 displays the output of the logistic regression model. The findings show that there is a statistically significant difference in the proportional reasoning skills according to gender (p-value=.025, OR=4.229), teaching experience (p-value=.001, OR=.109), and use of curriculum (p-value=.005, OR=.144).

Table 8. 5 Binary logistic regression

Demographic factors	B	S.E.	Wald	Sig.	Exp (B)
Gender (male=ref.)	1,442	0,645	5,001	0,025	4,229
Teaching experience (>10 years=ref.)	-2,220	0,649	11,709	0,001	0,109
Using curriculum (use it=ref.)	-1,940	0,691	7,887	0,005	0,144
Constant	1,139	0,663	2,952	0,086	3,125

Where OR=Exp (B) is the exponent of the coefficient B is the exponent of the coefficient B

As discussed in the literature, proportional reasoning is not static and some demographic factors may contribute to its development. The results indicate that teaching experience plays a significant role in solving mathematical problems requiring proportional reasoning as is supported by (Gencturk, 2012) The results in Table 6 show that teachers with teaching experience >10 years are more likely to have used appropriate proportional reasoning than those with less experience. This finding is important since it suggests that with teaching experience, teachers are likely to develop and improve their content knowledge and it is supported by much research (Friedrichsen et al., 2009; Kleickmann et al., 2013; Rice, 2010).

Furthermore, teachers who use the curriculum regularly (National curriculum statement Grade R-12) were also more likely to solve the tasks appropriately. This result suggests that teachers who spend time consulting the curriculum have developed their knowledge of the topic that was assessed. However, differences in proportional reasoning skills according to the factors of level of education and that of professional development participation are not statistically significantly different. A further interesting finding is that levels of proportional reasoning skills appear to be moderated by gender, with a male advantage. It is noted that female teachers were 4.229 times likely to display appropriate proportional reasoning skills than their male counterparts. This finding is interesting, since much research suggests that female school learners outperform male learners (for example TIMSS's (2015) results for South Africa).

8.3.3 Is there any relationship between teachers' proportional reasoning and their confidence about their knowledge?

Being mathematically or statistically literate depends on the person's level of understanding of mathematics. Furthermore, it is likely that a teachers' confidence in teaching mathematics topics in the classroom, may be influenced by their level of understanding of these topics. In the following analysis, confidence, I explore the connection between teachers' proportional reasoning skills and their ability to use mathematics and statistics in everyday situations. I also test whether there appears to be any relationship between their proportional reasoning and their confidence in teaching some mathematics or statistics topics.

Connection between teachers' proportional reasoning and their confidence about using mathematics and statistics in everyday life.

There are many illustrations that testify to the presence of mathematics in everything that we are doing. Every area of mathematics has its own unique applications to the different career options. Mathematics deals with logical reasoning and quantitative calculations. A confident and flexible understanding of these ideas is key to everyday estimation and mental calculation in contexts as diverse as shopping and budgeting, diluting mixtures, understanding scales on maps, interpreting probabilities and odds, and converting among metric units. Having an understanding of these ideas also plays an important role of being numerate and having the basic understanding of more sophisticated mathematical ideas. It is expected that teachers with well-developed proportional reasoning skills, will be easily able to identify and understand the importance that mathematics plays in the world, to make well-founded decisions as well as use and engage mathematics in ways that meet the needs of that individual's life. In this section, I explore the association between their levels of proportional reasoning skills and their confidence about using mathematics in everyday situations. In addition, I also investigate the relationship between their proportional reasoning skills and their personal confidence in topics related to proportional reasoning. Skinner, Edwards, and Corbett (2014) highlight two main types of chi-square test. The chi-square test for the goodness of fit which applies to the analysis of a single categorical variable, and the chi-square test for independence or relatedness apply to the analysis of the relationship between two categorical variables. I have used the chi-square test of independence to check for relationships between teachers' proportional reasoning and their confidence and beliefs about using mathematics in real life. The hypotheses that will be tested are:

H_0 : Teachers' level of proportional reasoning and their confidence about using mathematics and statistics in everyday settings, are independent i.e. there is no relationship between them.

H_1 : Teachers' proportional reasoning and their confidence about using mathematics and statistics in everyday settings, are dependent i.e. there is a relationship between them.

The results are presented in Table 8.6 and Table 8.7 show a positive relationship between the endorsement of the statements and their proportional reasoning skills. Thus, we conclude that at the 5% significance level those beliefs whose p-values are less than .05 are significant and we reject H_0 for these beliefs presented in Table 8.6. Therefore, we conclude that teachers' proportional reasoning and their confidence in using mathematics and statistics in everyday life are related.

Table 8. 6 Relationship between proportional reasoning and teachers' confidence about using mathematics and statistics in everyday settings

Personal confidence in using maths and stats in everyday life	Proportional reasoning		$\chi^2(df)$	P-value	
	Showing some understanding of proportional reasoning (%)	Appropriate reasoning (%)			
Given the price per square metre, I could estimate how much it would cost to carpet the lounge	Disagree	15(35,7)	2(6,1)	9.271 ⁽¹⁾	0,002
	Agree	27(64,3)	31(93,9)		
I often use mathematics/statistics to make decisions and choices in everyday life	Disagree	22(52,4)	5(15,2)	11.117 ⁽¹⁾	0,001
	Agree	20(47,6)	28(84,8)		
I can easily extract information from tables, plans and graphs	Disagree	12(28,6)	1(3,0)	8.413 ⁽¹⁾	0,005
	Agree	30(71,4)	32(97,0)		
I am confident that I could work out how many tiles I would need to tile my bathroom	Disagree	12(28,6)	1(3,0)	8.413 ⁽¹⁾	0,005
	Agree	30(71,4)	32(97,0)		

These results show that a person who has appropriate proportional reasoning skills is also more likely to be confident about applying mathematics or statistics in everyday context than teachers with lower levels. That is, teachers who had good proportional reasoning skills, were more confident of their mathematical and statistical literacy skills, suggesting that a person's confidence about their mathematical literacy skills may be influenced by their personal understanding of the content. Finally, I investigate whether teachers with good proportional reasoning skills are confident about their knowledge in related topics.

Connection between teachers' proportional reasoning and their confidence in teaching mathematics and statistics topics

In a similar manner, I tested whether there appears a relationship between proportional reasoning and items of teachers' confidence in teaching a variety of

mathematics and statistics topics. I used a chi square test of independence using a significance level of $\alpha = 0.05$. The hypotheses that were tested are:

H_0 : Teachers' proportional reasoning skills and their confidence in their ability to teach most of mathematics and statistics topics, are independent i.e. there is no relationship between them.

H_1 : Teachers' proportional reasoning skills and their confidence in their ability to teach most of mathematics and statistics topics, are dependent i.e. there is a relationship between them.

From Table 8.7, I conclude that at the 5% significance level for the topics below, whose p-values are less than .05 are significant and I reject H_0 for these topics presented in Table 8.7, and I conclude that there is a relationship between teachers' proportional reasoning and their confidence in their ability to teach a variety of mathematics and statistics concepts (i.e. for the statements with p-values $< .05$ which appear in Table 8.7).

Table 8. 7 Relationship between teachers' proportions and their confidence

Topics	Level of confidence	Proportional reasoning		χ^2 (df)	P-value
		Showing some understanding of proportional reasoning (%)	Appropriate reasoning (%)		
Fractions	Low	19(45,2)	5(15,2)	7.688 ⁽¹⁾	0,007
	High	23(54,8)	28(84,8)		
Decimals	Low	19(45,2)	6(18,2)	6.088 ⁽¹⁾	0,015
	High	23(54,8)	27(81,8)		
Percentages	Low	19(45,2)	4(12,1)	9.532 ⁽¹⁾	0,002
	High	23(54,8)	29(87,9)		
Ratios and proportions	Low	26(61,9)	12(36,4)	4.823 ⁽¹⁾	0,037
	High	16(38,1)	21(63,6)		
Simple probabilities understanding and calculations	Low	26(61,9)	10(30,3)	7.394 ⁽¹⁾	0,010
	High	16(38,1)	23(69,7)		
Ideas of sampling and data collection	Low	28(66,7)	13(39,4)	5.546 ⁽¹⁾	0,022
	High	14(33,3)	20(60,6)		

The results in Table 8.7 show that teachers who displayed appropriate proportional reasoning showed a higher level of confidence in teaching a variety of

topics related to proportional reasoning, such as fractions, decimals, percentages, ratios and proportions than those with lower levels of skills. This finding resonates with Beswick et al. (2006) who argued that being really numerate requires the knowledge and disposition to think and act mathematically and the confidence and intuition to apply particular principles to everyday problems.

8.4 Concluding remarks

This study explored teachers' proportional reasoning as evidenced in their responses to four mathematical tasks regarding the use of fractions, percentages as well as interpreting the information included in the pie chart.

The findings revealed that teachers struggled to solve the tasks based on proportions showing that their levels of proportional reasoning needs improvement. This insufficiency of the knowledge of mathematics content was reflected in the large numbers of inappropriate answers to these tasks, for instance only 20.0% teachers responded correctly to the task asking them to respond whether smoking causes LD in the given task. Also, approximately 50% teachers managed to make reference to the whole for the problem of Mary and John and for the problem of the pie chart, whereas 69% gave detailed approaches in solving 90% of 40. This result shows that the teachers were able to work out simple calculations on percentage but were not able to cope with situations which required relative comparisons involving proportions. Their struggles in solving the tasks based on proportions indicate that their proportional reasoning skills need improvement.

Many teachers revealed various misconceptions in solving these tasks, which is linked to a poor conceptual knowledge about fractions, proportions and percentages (Khashan, 2014). Many teachers, in trying to reason about the relationships in the tasks, made decisions without making reference to the whole, even though this was a crucial aspect of one task. For the problem of Mary and John, many teachers reasoned that $\frac{1}{4} < \frac{1}{2}$ always so there was no way that Mary could spend more than John. Moreover, teachers demonstrated misconceptions in solving the data contained in 2x2 contingency table where most teachers confirmed that LD is caused by smoking because they did not look at both marginal totals, they just used one of them. This limited them in making an appropriate response. As discussed in the literature, several

real life tasks necessitate proportional reasoning which includes the capacity of interpreting situations in comparative terms (Dole et al., 2015).

It is therefore teachers' responsibility to develop their proportional reasoning by using a variety of resources in order to acquire sufficient knowledge and skills so as to understand what proportions are, since a person cannot teach what s/he does not know. Insufficient proportional reasoning also disadvantages a person in terms of the capacity to think logically and to defend everyday conclusions (Molefe & Brodie, 2010). Mathematics and Statistics are applied in different areas such as government planning, medicine, psychology, large companies, banks etc. Thus, developing proportional reasoning is one of the factors in terms of improving the use of numeracy in real worlds.

Shulman (1986) advises that teachers need to know not only what something is but why it is so, and that content knowledge must focus on knowing what and knowing how of a discipline. Therefore, teachers need to know the procedures used to generate knowledge in their field as well as to develop their conceptual knowledge (Khashan, 2014). They also need to focus on using real life and practical examples and other interesting models that increase learners' interest towards mathematics and statistics.

In this study, the findings presented in Table 8.7 brought a new insight about the importance of proportional reasoning in developing teachers' own confidence in teaching some mathematical and statistics topics. The results suggest that a person's confidence about their mathematics knowledge and their confidence about their mathematical literacy skills is influenced by their personal understanding of the content. This finding is important and suggests that if teachers could have high proportional reasoning skills they would be more likely to apply mathematics and statistics in everyday situations Beswick (2007) adds that confidence in teaching mathematics is of specific importance to teachers' practices, reflected in enjoyment of mathematics for its own sake, while some authors suggest that teachers' lack of confidence may be due to a lack of background knowledge (Appleton, 1995). Thus, the findings from Table 6 support the conclusions of these authors that the use of mathematics in our society depends on the person's content knowledge.

This finding is important and suggests that if teachers have a high level of proportional reasoning, they would be more likely to act mathematically and statistically in everyday situations. This study showed that more experienced teachers were more successful at solving the tasks than their less experienced counterparts. This suggests that as teachers gain teaching experience they are able to improve their content knowledge (Friedrichsen et al., 2009; Kleickmann et al., 2013; Rice, 2010). The study also found that teachers who used the curriculum regularly showed higher proportional reasoning skills than those who did not. Even though attendance at workshops did not show any impact in terms of developing proportional reasoning in this study, it may, however, be a mechanism to improve teachers' content knowledge (Hilton et al., 2013; Stols et al., 2007; Worden, 2015). It may also be beneficial for teachers to attend professional development courses which help them to unpack the curriculum which they need to teach. It was also found that a greater proportion of male teachers had appropriate proportional reasoning skills compared to their female counterparts. This is an unexpected finding, since a male advantage in mathematics achievement has not often been reported in the literature in recent times. In terms of difference in achievement in mathematics in South Africa, some studies show that the gender gap in mathematics at school level has narrowed and has even seemingly been reversed (Reddy et al., 2016). Our study which was conducted with teachers and recent research conducted with in-service Mathematical Literacy teachers from KZN found a significant male advantage where 68% of male teachers completed the in-service course in minimum time compared to the 50% of female teachers who achieved the same result (Bansilal, 2015). In the study with ML teachers, female teachers accounted for 75% of the participants, while in this study the proportion of male and female teachers were roughly equal. The result of this study about the gender difference in mathematical achievement of teachers in KZN suggests that further research in this area is required.

Overall, it is clear that teachers need to make an effort to become experts in the mathematics they teach, as they are the mediators of knowledge to their learners. The study recommends that proportional reasoning should be emphasised at school level since it empowers both teachers and learners to think and act mathematically and statistically not only in the classroom, but also in the real world.

The next chapter focuses on teachers' suggestions for improving teaching and learning of mathematics and statistics.

CHAPTER IX. EXAMINING TEACHERS' STRATEGIES ABOUT IMPROVING TEACHING AND LEARNING MATHEMATICS AND STATISTICS

9.1 Introduction

The Trends in International Mathematics and Science Study (TIMSS) is an international study in which Grade 5 and Grade 9¹ South African learners participate. In 2015, learners from this country were ranked second to last out of a total of 45 countries that partook in the study, both for the Grade 5 and Grade 9 mathematics groups. The report for the Grade 9 study lead Reddy and colleagues (2016) to argue that education and learning are shaped by home, school and community environments with all of these exerting influences of different strengths and different directions. Some learner factors that seemed to influence the TIMSS scores obtained were confidence in mathematics, gender, experience of bullying, frequency of absence from school, education levels of parents and home resources. School factors such as school location, school safety, and amount of importance placed on achievement were also identified as factors of influence on the TIMSS results. Other studies point out that low achievement in rural schools may be a result of limited school resources such as school furniture, telephones, photocopiers, learner resource material, electricity, water ablution facilities and audiovisual equipment (Christie, Sullivan, Duku, & Gallie, 2010; Gardiner, 2008; Sao, 2008).

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

By 2030, South Africans should have access to education and training of the highest quality, leading to significantly improved learning outcomes. The performance of South African learners in international standardised tests should be comparable to the performance of learners from countries at a

¹ For most countries, Grade 8 learners write the test, but in South Africa, it was Grade 9 learners who wrote the test.

similar level of development² and with similar levels of access (National Planning Commission, 2013, p. 296).

Major concerns of the DoBE of South Africa, are that teachers need support in developing their professionalism and in keeping up activities to improve their teaching skills. In addition the Education Department would like to ensure that teachers teach the stipulated content at the required cognitive levels (DoBE, 2017). The Department of Education in KwaZulu-Natal (KZN DoE, 2016) has identified that inadequate professional development activities of teaching staff are a major concern and included targets to train over 40000 teachers in the teaching of mathematics in 2016. The DoBE (2011a) is also concerned that teachers should improve their level of expertise, develop effective teaching skills, improve their subject knowledge amongst other things in order to achieve effective learning. Various strategies have been put forward to improve learners' understanding, such as improving teachers' content knowledge, improving levels of teachers' formal qualifications, improving teachers' pedagogic knowledge, improving the functionality of schools as well as improving curriculum coverage (Bansilal et al., 2014; Van der Berg, Taylor, Gustafsson, Spaul, & Armstrong, 2011).

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

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

² Some countries with similar levels of development as South Africa are Angola, Turkey, Mexico and Zimbabwe

ideas. I explore what South Africa mathematics teachers think, need or suggest about how the teaching and learning of mathematics and statistics could be improved.

9.2 Literature Review

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

There are other factors besides just the quality of teachers and teaching which influence the performance of learners particularly in mathematics. Improving learner achievement is not a simple endeavour because of the multidimensionality of the various factors which affect learner achievement in mathematics. The TIMSS study report Reddy et al. (2016) investigated the role of the socio-economic status of learners and showed that the average score achieved by the poorest learners (those who attend the no-fee public schools) was 341. In contrast the more affluent learners (who attend the public fee paying schools) achieved 423 points on average, a difference of 82 points. Note that on the TIMSS achievement scale, a score of 500 corresponds to the mean of the overall achievement distribution (Reddy et al., 2016).

The study also revealed that learners whose primary language was the same as the language of the test, achieved on average 60 points higher than those for whom the language of the test was a secondary language.

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

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

Other scholars like Ebersöhn and Eloff (2004) and Felder and Brent (1999) suggest that teachers should incorporate games in teaching since through the use of games in learning mathematics, learners learn the new concepts and develop their practices and problem solving practices. Some other studies have shown that integration of technology in teaching mathematics (Moore, 2012) and statistics (Baharun, 2012; Lesser & Groth, 2008) may improve students' understanding. When teachers used technology, especially the internet, in teaching and learning, they gain

new insights into the different strategies that they could use in the classroom. Purcell et al. (2013) describe the importance of the internet and digital tools in teachers' work of teaching. They state that "the greatest impact of the internet and other digital tools on their role as teachers has been access to more content and material for use in the classroom and a greater ability to keep up with developments in their field" (p.51).

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

Garfield (1995) and Fauziah and Saputro (2018) suggest that statistics teaching and learning can be enhanced by the use of a variety of assessments and skills and the use of software and computer simulation. In their review, Tishkovskaya and Lancaster (2012) found that students in some studies expressed negative attitudes towards statistics because they possessed limited prior mathematical and statistical knowledge. These authors also suggest that, in teaching statistics, teachers should use innovative approaches and a variety of the assessment strategies involving statistical reasoning.

The construct of statistical knowledge for teaching (SKT) which is used to describe teachers knowledge and skills in the teaching of statistics, has received much attention in recent studies (Burgess, 2008, 2009). Authors such as Maxine Pfannkuch (2008) have focused on dimensions of SKT highlighting that it is necessary for teachers to have knowledge about statistical literacy, thinking and reasoning to improve statistics teaching and learning. In South Africa, statistics has traditionally been taught by using lecturing methods covering the mechanics of statistical methods and the theory of probability and mathematical statistics where students' contribution is restricted (Steffens & Fletcher, 1999; North & Zewotir, 2006). Along the same lines, Wessels (2008) reported that South African teachers did not have sufficient statistical

content and pedagogical content knowledge to teach statistics since the teachers had had no effective training in statistics. Scholars suggest that building the capacity of teachers, as mediators of the curriculum, may be the ultimate answer (Moloi, 2005). It has become evident that professional courses such as the maths4stats course have contributed to developing teachers' skills in teaching statistics. The maths4stats project was developed in 2007 by Statistics South Africa (StatsSa) which is the National Statistics Office. The aim of this project is to improve statistical teaching in South Africa schools around the country (North & Scheiber, 2008; North & Zewotir, 2006)

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

9.3. Results and discussion

9.3.1 Suggested strategies

The results of the study are presented below arranged according to research questions. There were six main categories emanating from the data with respect to the teaching of mathematics and statistics as shown in Table 9.1. The descriptions are presented in more detail thereafter. Note that the teachers' responses are quoted verbatim without any editing.

Table 9. 1 Strategies about improving maths and stats

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

9.3.1.1 Increasing motivation and interest of learners (IM)

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

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

statistics) were directly related to efforts that could decrease mathematics anxiety, for example “Ensure that I teach them with enthusiasm to eradicate mathematics phobia”.

The phenomenon of mathematics anxiety has long been recognised as a negative influence on learners’ achievement. Schukajlow (2015) found that many learners are afraid of mathematics, and they often perceive mathematics as difficult. Some studies which have been conducted on the issue of learners’ attitudes towards mathematics e.g. (Buckley, 2013; Hembree, 1990; Schukajlow, 2015) argue that mathematics’ anxiety can contribute to poor performance in mathematics activities. The teachers’ concern also came to the fore in our study where teachers’ comments suggest that they are concerned because their learners do not see mathematics or statistics as interesting and important. They emphasised that they would like to provide learners with opportunities to improve their learners’ love of mathematics and reduce their fear about the subject. In the TIMSS in 2015, learners were asked to respond to questions about their self-concept regarding their ability to learn mathematics. The TIMSS 2015 results revealed a positive relationship between learners’ belief in their ability and their performance, with the scores of confident learner learners being 89 points on average higher than those of non-confident learners.

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

A strong thread running through many of the responses was the need to show why mathematics or statistics was important and why learners should learn the subject. There were six similar comments for mathematics and for statistics arguing that learners needed to be convinced about why we study mathematics/statistics and how it was related to other subjects. They indicated that improving learners’ interest in the subject would help the students to appreciate the importance of mathematics/statistics, increase their enthusiasm and support them in creating a

positive attitude towards the subject, because mathematics is the key to everything they do in life. A suggestion by six (one for mathematics and five for statistics) was that learners' motivation could be improved by using self-directed activities which allowed learners to take responsibility for their own learning of mathematics and statistics. An example is "I would allow learners to create their own scenarios".

9.3.1.2 Clearer explanations and more practice (TEB)

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

Other teachers suggested spending more time teaching learners in order to improve their knowledge and by setting extra work. One teacher explained that s/he was prepared to start school at 6.30 A.m., effectively adding 1 ½ hours to the day: "Take more time with them and using extra time and holidays when periods starts at 8:00 am. I will start at half past 6 am it was explained that learners need to be given enough time to understand mathematics because these are domains that require high levels of reasoning". The strategy evoked by the some teachers in regard to increasing class time must be treated with caution. An increase in instructional time can be risky because it may reduce the cognitive disposition of the pupils because of the fatigue that might result from the addition of school hours.

Another suggestion emphasised the need to focus on the big or key ideas of a concept when teaching a concept: "First the key concepts and key word and explain that key word and give the formulas that are needed to be used. It is imperative to

know key concepts so that you can understand the related content". Some teachers conveyed their belief in the power of practice: "Tell the learners that in order for them to understand mathematics they will need to practice every day". These suggestions reflect some of the concerns in South Africa that learners do not know enough mathematical materials (DoBE, 2017).

9.3.1.3 *Making links to real life (RL)*

Under this category, I considered broad suggestions about using real life examples in the classroom to improve the participation and engagement of learners. There were 15 (11.0%) and 20 (17.0%) strategies provided in mathematics or statistics respectively. These comments indicate that teachers see the need for learners to see the real-life applications of mathematics and statistics. They believed that linking mathematics to real life enables learners to participate in other fields and not only in the classroom. They also felt that the application of content to real-life situations supports learners in becoming mathematically literate, and helps them to deal with daily life situations. In their opinion, teaching statistics by linking it to real life will enable their learners to use the knowledge gained in the classroom in their own life experience. They need to understand that statistics is also applied in real life. Teachers also remarked that using real life examples helps learners apply statistics in many services such as economics, business, money market and their financial planning.

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

9.3.1.4 Using practical or concrete examples (UPE)

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

9.3.1.5 Professional development (PD)

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

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

Teachers noted that they need to grow in their field and gain an understanding of more pedagogical strategies that they can use in class to assist their learners. Many

teachers suggested that they would attend statistics workshops in order to improve their knowledge in statistics so that they could help learners understand the calculations using statistics in daily life. Some teachers mentioned that statistics workshops help them to learn much more about statistics (data handling). They also believed that attending workshops enabled them to develop their own levels of statistical literacy, improve their knowledge and could lead to formal qualifications. For example: “Need more courses or workshops and I need the diploma in mathematics”.

9.3.1.6 Using investigations and projects (INV)

I also considered suggestions about possible investigations or projects that could be carried out. Investigations are used to “discover rules or concepts and may involve inductive reasoning, identifying or testing patterns or relationships, drawing conclusions, and establishing general trends” (DoBE, 2011b, p. 295). Projects are also used to help learners understand mathematics rules and its application in real life. There were five suggestions made for mathematics and three times as many 15 (12.7%) for statistics. This difference is likely because the teachers were attending a statistics education workshop meant to improve their knowledge of statistics. Hence, the exposure they received to possible statistics investigations may have motivated them to the value of conducting investigations. An example of such a suggestion was: “I would make use of investigations that involve learners gathering into themselves, then analysing and interpreting”. DoBE (2011b) also recommends that mathematics teachers should involve investigations as the way of assessing students’ knowledge, as they help them to develop their level of creativity and thinking critically.

9.3.2 Factors influencing the strategies mentioned

In analysing the various strategies, I found that some teachers presented many strategies. For example, one teacher wrote “Motivate learners to see mathematics as for other subject to change attitude. Plan activities that would excite learners in class. Involve learners by making them see how the difference between population to sample, allow learners to collect, analyse and present data”. However, there were other teachers who seemed to be content with providing just one strategy: “Discourage use of calculators”. The difference seems to be related to the teacher’s willingness to reflect about the various issues that impact on the teaching and learning situation. Teachers who presented multiple suggestions were assumed to have spent more time

engaging in the issue at hand than others who presented only one suggestion. I then investigated whether certain demographic factors appear to be associated with the teachers' tendency to discuss multiple strategies and I also looked at the role of demographic factors in suggesting specific strategies.

9.3.2.1 Details of the binary logistic regression

Binary logistic regression was used to model teachers' suggestions and teachers' demographic factors, given that the response variable is dichotomous (Harrell, 2015; Hellevik, 2009). Logistic regression is used to determine the relationship between the dependent variable response or outcome variable and a set of independent or predictor or explanatory variables. Logistic regression assumes that the response variable is categorical. When the response variable has two outcomes (e.g. inappropriate answer/ appropriate answer; failed/ passed), the model is termed binary logistic regression.

The independent variables considered in this study include gender, age, teaching experience, using curriculum in teaching and learning as well as level of education of the teachers. Table 9.2 reflects the response variables used in the models. The response variables were coded using dummy codes, such that 0 indicates a single strategy and 1 indicates multiple strategies expressed by teachers in terms of improving mathematics and statistics concepts – this made it binary. Therefore, the reference category was the highest code group as the comparison group. The analysis was made using IBM SPSS version 23 (George & Mallery, 2016).

Table 9. 2 Description of the response variables

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

Table 9.2 displays the number of different strategies suggested by teachers in relation to improving teaching and learning mathematics and statistics. It can be seen in Table 9.2 that teachers were more likely to suggest a single strategy towards improving mathematics than statistics teaching and learning. On the other hand,

teachers were more likely to express multiple strategies towards improving statistics than mathematics teaching and learning. This is a positive development and it is expected that their learners will benefit by the increased attention of their teachers to how they can improve their teaching statistics. The fact that teachers were able to come up with more strategies for improving the teaching of statistics may be a direct consequence of them attending the in-service statistics education course within which this research was located. The exposure to issues about the teaching of statistics would undoubtedly have increased their knowledge of different issues on the subject.

9.3.2.2 Model Fit

In order to assure the goodness of fit for the model of improving mathematics and statistics teaching and learning, the omnibus test statistic was used to assess whether there was a linear relationship between the probability of improving mathematics and statistics using a single strategy or multiple strategies and the demographic factors. An omnibus test statistic with p-value less than 0.05 implied that the logistic regression could be used to model the data. Model selection was done using the standard method (Enter) (Muchabaiwa, 2013). This means that all variables in a block are entered in a single step. Table 9.3 indicates that chi-square values of all three tests are the same and their probabilities are less than 0.05 for the two models. This indicates that at least one of coefficients of the predictors is not equal to zero.

Table 9. 3 Omnibus tests of model coefficients

		Improving mathematics (model 1)			Improving statistics (model 2)		
Test		Chi-square	DF	P-value	Chi-square	DF	P-value
Step 1	Step	27,500	5	0,000	25,124	5	0,000
	Block	27,500	5	0,000	25,124	5	0,000
	Model	27,500	5	0,000	25,124	5	0,000

Where DF = degrees of freedom, or the number of factors included in the model

Model summary statistics was checked in Table 9.4. I note that Nagelkerke's R^2 are 0.411 (for maths) and 0.380 (for stats), which indicates that the models are good.

Table 9. 4 Model summary

Improving mathematics				Improving statistics		
Step1	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square	-2 log likelihood	Cox & Snell R Square	Nagelkerke R Square
	75.390 ^a	0,307	0,411	78.835 ^a	0,285	0,380

Furthermore, Hosmer-Lemeshow (H-L) goodness-of-fit statistics (Hosmer & Lemeshow, 2000), were also used to assess the model fit. This test compares the predicted values against the actual values of the dependent variable. The method is similar to the chi-square goodness of fit. A very small chi-square of H-L test statistic is desirable and a p-value greater than 0.05 indicates that the model is acceptable (Hosmer & Lemeshow, 2000). The findings reflected in Table 9.5 indicate that the chi-square values of H-L test and non-significant p-values (the values are greater than 0.05), were improved after removing insignificant factors. Therefore, this indicates the goodness of fit of the models.

Table 9. 5 Hosmer and Lemeshow test

Improving mathematics				Improving statistics		
Steps 1	Chi-square	DF	P-value	Chi-square	DF	P-value
	6,967	8	0,540	3,077	7	0,878

Where df = number of groups -2

9.3.2.3 Results from the logistic regression

Tables 9.6 and 9.7 present the parameter estimate of demographic factors fitted with teachers' strategies. The findings presented in Table 9.6 show that, as compared to males, female teachers were more likely to suggest multiple strategies in relation to improving mathematics teaching and learning rather than single strategy (p-value = 0.010, OR = 4.540).

Table 9. 6 Parameter estimates for teachers' strategies about improving mathematics

Factors		Coefficient (β)	S. E	Wald	P-value	Exp (β)
Gender (Male = ref)	Female	1,513	0,591	6,550	0,010	4,540
Attended previous mathematics workshops (Yes=ref)	No	-1,625	0,651	6,223	0,013	0,197
Use curriculum (used it = ref)	Not used	-1,938	0,640	9,165	0,002	0,144
Age (>40 = ref)	≤ 40	1,614	0,662	5,954	0,015	5,025
Constant		-0,399	0,664	0,362	0,548	

It is noted from Table 9.6 that teachers aged ≤ 40 years old are more likely to express multiple strategies about improving mathematics than teachers aged >40 years old (p-value = 0.015, OR = 5.025).

Table 9. 7 Parameter estimates for teachers' strategies about improving statistics

Factors		Coefficient (β)	S. E	Wald	P- value	Exp (β)
Attended Mathematics Workshops (yes=ref)	No	-1,541	0,580	7,068	0,008	0,214
Using curriculum (Used it =ref)	Not used	-1,270	0,627	4,099	0,043	0,281
Level of Education (postgraduate or above =ref)	Undergradua te or lower	-2,051	0,639	10,302	0,001	0,129
Constant		2,166	0,777	7,775	0,005	

Where OR = Exp (β)

I further found that young teachers hold more positive beliefs towards mathematics and statistics teaching, compared to older teachers. For instance, more of the younger teachers agree that teachers of mathematics should be fascinated with how learners think and be intrigued (interested) by alternative ideas (55.7% versus 44.3%), and statistical material is best presented in an expository style: demonstrating, explaining and describing concepts and skills (59.4% versus 40.6%), etc. This is supported by the analysis of the specific suggestions according to age, where younger teachers provided 26 suggestions related to improving teacher explanations (TEB) as compared to only 10 strategies provided by the older group. Furthermore, the group

of younger teachers provided 53 suggestions that were related to using practical examples (UPE) and making links to real life (RL) whereas the group of older teachers provided only 33. Day and Gu (2007) found that there is a variation in teacher effectiveness at every stage of the teaching career, and I see in this study that younger teachers are more willing to provide various strategies that they think will improve the teaching and learning of mathematics or statistics than older teachers. It may be that younger teachers are also more enthusiastic and motivated since older teachers are more likely to experience burnout as shown in the study by (Philipp & Kunter, 2013) where they found that the level of emotional exhaustion increased with age in their sample of 1939 German teachers.

Furthermore, the findings indicate that teachers who said they used the curriculum document, were more likely to suggest multiple strategies in improving mathematics and statistics teaching and learning than those who did not use the document (p-value = 0.002, OR = 0.144 and p-value = 0.043, OR = 0.281). This finding supports the importance of teachers engaging with the curriculum documents. The curriculum documents are a road map for teachers and they should refer to them often (Makas, 2009). As the findings indicate, teachers who use the curriculum documents seem to be aware of more strategies than teachers who do not do so.

In addition, Table 9.7 indicates that teachers whose highest level of study is an undergraduate or lower qualification were less likely to express multiple strategies in terms of improving statistics than teachers whose highest level of study is a postgraduate qualification (p-value = 0.001, OR = 0.129). On its own, this result may seem innocuous but it is helpful to see this within the South African teacher training context as elaborated in the literature review. It is an important finding that a practising mathematics teacher with a postgraduate qualification in teaching demonstrates a broader understanding of educational issues related to the teaching of mathematics and statistics. The teachers who hold postgraduate qualifications are the ones who either completed their initial training at universities or have studied further at university to raise their level of qualification. Table 9.6 and Table 9.7 further indicate that teachers who said that they have attended mathematics or statistics workshops are more likely to express multiple strategies for improving mathematics and statistics (p-value = 0.013, OR = 0.197 and p-value = 0.008, OR = 0.214). This finding indicates the importance of professional learning in terms of developing teaching and learning. In

fact, an analysis of the suggestions made by teachers with respect to the category of professional development, shows that the teachers with a 3-year or lesser qualification made 23 suggestions with respect to attending workshops to improve their knowledge or qualification, while the postgraduate group did not make any such suggestions. This finding is significant, in terms of the South African context where teachers from teacher training colleges have only a 3-year qualification and find it difficult to upgrade their qualification (Bansilal, 2012), because it demonstrates that teachers want the opportunity to improving their teaching qualifications.

9.4 Conclusion

In this chapter, I reported on the suggestions made by teachers about how they could improve mathematics and statistics teaching and learning. As classroom practitioners, teachers know the problems they encounter and are hence well positioned to offer insight about how these problems could be improved. This study provides insights into South African mathematics teachers' suggestions for improving the teaching and learning of mathematics and statistics.

Many suggestions made by teachers have been identified in research conducted throughout the world. The findings revealed that teachers' suggestions were mostly concerned about improving motivation, interest and knowledge of their learners in mathematics. The teachers suggested various ways in which they could improve motivation and emphasised the use of concrete examples and manipulatives when mediating concepts. There was also a call for making real-life links to the mathematics and statistics topics. These suggestions may indicate how much teachers struggle to keep their learners motivated and interested in mathematics in a rapidly changing world. In the discussion of the results for each theme, links between the teacher's suggestions and research findings were elaborated, illustrating that value of the teachers' suggestions. Furthermore, it is important that policy makers and professional development interventions take note of the strategies proposed by the teachers since they are well placed to offer the suggestions for improving the teaching and learning mathematics and statistics.

The teachers were also introspective about their own development and made suggestions regarding their own teaching approaches. They said that they needed to attend more workshops in order to improve their methodology of teaching mathematics

and statistics, and commented that these workshops would help them to use modern methods. In addition, I investigated whether there appeared to be certain factors which influence the teachers' willingness to mention multiple strategies. Although I looked at the difference between mentioning multiple or a single strategy, it may be that some teachers do believe that multiple strategies should be used in the teaching and learning of statistics, but are not *aware* of a variety of strategies to do so due to a lack of professional development.

The study revealed some interesting associations between the frequency and types of suggestions and the factors of age, gender, qualification levels and familiarity with curriculum documents. It was found that younger teachers were more likely to present multiple strategies, suggesting greater enthusiasm for tackling the numerous problems faced by teachers. The study therefore suggests that certain groups of teachers (grouped according to the factors considered in the study, such as age) who had less strategies to suggest may be in greater need of professional development. This finding would be useful for professional development agencies in South Africa to take into consideration when planning interventions.

Young teachers were also more likely to suggest using practical and real-life examples than older teachers. It may prove fruitful to investigate further differences between younger and older teachers since teachers under 40 years are more likely to have graduated from university-affiliated institutions and those who are older were more likely to have been trained in the teacher training colleges.

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

It is important to acknowledge the limitations of the study. For instance, the participants were not randomly selected. The study was conducted with the teachers who were selected purposively by the Department of Basic Education. Thus, the findings are based on a group of teachers who were attending professional

development courses in statistics. Furthermore, of the 136 teachers who participated in the programme, only 75 teachers agreed to participate in the study. In future studies, I hope to have access to larger samples which will allow us to generalize our findings. A further limitation is that I used only a questionnaire to probe teachers' views. Perhaps interviewing small groups of teachers may provide further support for the findings.

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

CHAPTER X. DISCUSSION

In this section, I discuss whether this study responded to the research questions mentioned in the introduction. The responses to the research questions are discussed below.

10.1 Research question 1: What are the teachers' perceptions towards their teaching practices in teaching mathematics and statistics concepts?

Under this research question, I explored how teachers set learning objectives they hope will be achieved by the end of the courses, how they introduce a topic in the classroom and how their learners respond to the mathematics and statistics topics. Secondly, I looked at the teaching methods and assessment strategies they use to teach and assess mathematics and statistics learning and understanding. Thirdly, I examined their confidence and beliefs in teaching a variety of mathematics and statistics topics. Then, I explored how they work across the curriculum to contribute to good teaching and learning. Finally, I examined how they use technology as a tool which facilitates teaching and learning mathematics and statistics.

10.1.1 What do the teachers' written responses reveal about their understanding of lesson objectives?

This study investigated how teachers set learning objectives of the lesson that they hope will be achieved by the end of the course. In order to respond to this research question, teachers were requested to write down the objectives they think are appropriate when they teach the topic of their choice (they were presented with a list and were requested to choose one topic). The findings showed that 8 (10.7%) teachers did not manage to set learning objectives, 5 (6.7%) came with irrelevant objectives, 3 (4%) teachers gave reasons why the concept is taught, 9 (12%) gave an explanation of the topic or procedure and 50 (66.7%) gave an appropriate objective of the lesson. Overall findings show that at least half of the teachers were able to identify appropriate objectives that could guide them in shaping maths and stats topics. The remaining 25 (33.3%) teachers need to know that they are learning drivers and that without clear learning objectives, or if learning activities do not relate to the

objectives and the content that they think is significant, the methods of assessment that are thought to direct the success of both learner and teacher, will be at best ambiguous and irrelevant. Board (2016) highlights that instructional objectives specify exactly what is supposed to be learned, and that they are helpful to the teacher as well as the learner. The identification of learning objectives helps teachers to make learning understood and also their learners to communicate the teachers' intentions to them. Thus, objectives allow them to give students information that can better direct their learning efforts and monitor their own progress (Ambrose et al., 2010).

10.1.2 How do teachers describe their introductory approach to particular topics?

This study investigated the strategies that teachers use to introduce mathematics and statistics topics in the classroom. Teachers were then requested to respond in open-ended questions the different ways that they use to introduce these topics. After coding teachers answers qualitatively, I found that some teachers did not report any strategy about introducing a topic in the classroom (4 or 5.9% cases) Besides this, teachers reported that they ask questions (14 or 18.18% cases), make links to previous studies (10 or 12.99% cases), use practical examples and real life examples (36 or 43.4% cases) and use explicit instruction (24 or 29% cases) when they introduce mathematics and statistics topics in the classroom. Moreover, among 66.7% of teachers who managed to set learning objectives, 64.1% of them managed to make connections between learning objective and introducing a topic in the classroom. In terms of introducing those concepts, the findings indicate that teachers reported a variety of methods to introduce mathematics and statistics in the classroom; however, further analysis indicated that many teachers focus on a single approach. It is also noticeable that teachers did not make many references to the use of manipulative approaches (Ross, 2008) which can be useful in a mathematics classroom.

10.1.3 What are teachers' perceptions of their learners' responses to their teaching?

I also explored whether learners have an understanding of mathematics and statistics. This was discussed in Chapter III where I asked teachers to report how their learners respond to these topics, using open-ended questions. Ball et al. (2008, p. 401) suggest teachers should have KCS which enables them to anticipate what

students are likely to think and what they will find confusing. Thus, this study used teachers' answers to explore learners' understanding of these topics. The findings revealed that some teachers did not manage to evaluate their learners (8 or 10% cases), others said that their learners struggle to understand the topic (7 or 9% cases), others conveyed that their learners pose more questions (8 or 10% cases), others reported that their learners share and participate well (5 or 6% cases), others reported that their learners show a positive attitude and enjoy the topic (6 or 8% cases) and others revealed that learners show understanding and answer the questions related to maths and stats topics correctly (36 or 45% cases). Briefly, the findings indicate that less than half of the participants responded that their learners showed an understanding of mathematics and statistics concepts. Analysing the link between teaching practices, the findings revealed that less than half of the teachers (26.7%) managed to make a link by reporting appropriate learning objectives to be achieved by the end of the course, appropriate strategies to introduce a topic in the classroom, the methods they use to teach and assessments and showed evidence of learners' understanding.

This lack of ability in making the connection between teaching practices may be due to the fact that teachers possess a limited mathematical knowledge for teaching (Ball et al., 2008) or statistical knowledge for teaching (Burgess, 2008, 2009). Further studies suggest that teachers should hold a sufficient PCK to be able to identify learners' misconceptions, design suitable teaching material and also judge the appropriateness using examples based on the concept (Shulman, 1987; Suffian, 2010). It is therefore important that professional development workshops focus on building up the PCK of teachers and do not only focus on teaching them the content. The findings also indicate a number of teachers who did not report their ideas in terms of how learners respond to the topics. This may indicate the teachers' need of more experience in the area of KCS so that they can develop skills in predicting students' thinking on specific tasks. Previous researchers highlighted that there are still under-qualified or unqualified mathematics teachers in South Africa (Mji & Makgato, 2006) which may be the biggest factor contributing to learners' failure in mathematics and statistics. Therefore, professional courses are urgently needed in this area to help teachers improve their PCK in terms of knowing their learners' thinking.

10.1.4 What are the different approaches used by teachers in their teaching and assessing of mathematics and statistics topics in KwaZulu-Natal schools?

Apart from introducing a topic in the classroom, the study investigated the teaching methods and assessments strategies that teachers use to teach mathematics and statistics concepts. Teachers were encouraged to write freely about the different teaching methods and assessments they use to teach these topics using open-ended questions. The findings revealed that teachers are more comfortable in using teacher-led instruction (24 or 23.1% cases) where teachers explain a concept or focus on the use of the chalkboard or present a demonstration or tell learners what the concept is. The next method is classroom discussion (17 or 16.4% cases) and group teaching (17 or 16.4% cases), concrete or practical instructional material (13 or 12.5% cases), individual work (7 or 7.7% cases), etc. These findings indicate that teacher-led instruction is still a predominant method in teaching mathematics and statistics, even though it is recognized not to develop conceptual understanding of mathematics (Nyaumwe et al., 2004). It is therefore up to teachers to involve the new strategies such as learner-centred methods (Brodie, 2006; Chisholm & Leyendecker, 2008; Yushau et al., 2005) as well as manipulatives, real-life application, integration of technology devices, and games (Moore, 2012). All these approaches are known to improve learners' understanding of mathematics and statistics.

The study also analysed the teachers' responses to a questionnaire to analyse how likely they were to use more than a single method and assessment to teach mathematics and statistics. This was done by classifying different teaching methods and assessment strategies reported by teachers into single and multiple teaching methods and assessment strategies. The findings revealed that 36 (48%) teachers seemed to be more comfortable in using a single approach in teaching statistics topics than in applying multiple methods. I also noted that teachers were more likely to apply more than one method in teaching mathematics than in teaching statistics topics and to use more than one assessment in enhancing mathematics than statistics understanding. This finding is surprising, given that statistics topics are generally more contextualised and it should therefore be easier to apply innovative pedagogies in the teaching of statistics. The teaching of statistics in the classroom can be made more interesting by the use of real life examples such as media reports and newspapers articles. These readily available resources can be used to develop learners' aptitude

in terms of interpreting statistical ideas. Teachers could also build in opportunities of working with real data sets and simulated computer based activities, since statistics has so many real-life applications. Such activities could help learners explore statistical concepts while engaging in data collection and analysis. The use of these innovative pedagogies can promote statistical thinking, reasoning and construction of their knowledge.

Moreover, teachers were requested to describe the type of assessment they use to enhance mathematics and statistics understanding. The findings revealed that teachers mostly use formal assessments (39 or 30.1% cases), formative assessments (35 or 26.9% cases), or informal assessments (30 or 23% cases), etc. These different types of assessments were all mentioned to develop students' understanding (DoBE, 2011b). This finding indicates that teachers are aware of the type of assessment; however, it appeared that 44 (58.7%) teachers still focus on a single type of assessment instead of multiple assessments.

The transformation of classrooms into sites where learners develop positive mindsets and become confident users of mathematics is a difficult task (Boaler, 2016). Therefore, appropriate support from professional development initiatives can help the teachers move towards creating such classrooms. As South Africa is an emerging resource economy, there is an urgent need to increase the number of mathematically proficient learners who enter the economy each year, which means that mathematics teachers' teaching and assessment practices need to be made more effective. Generally, teachers should be encouraged to improve their way of teaching by moving beyond a reliance on teacher-led instruction. More particularly, training in statistics education is needed to help mathematics teachers manage the wider and more relevant statistics curriculum so that learners will be statistically literate when they leave school (Wessels, 2008:5).

10.1.6 What is the status of teachers' confidence and beliefs in teaching mathematics and statistics concepts?

The study further investigated confidence levels of teachers regarding the teaching of various mathematics and statistics topics. It also examined teachers' beliefs in their ability to use the mathematics and statistics required to meet the general demands of everyday life as well as their beliefs in their ability about mathematics and

statistics in the teaching and learning process. An instrument was constructed and subsequent feedback revealed that teachers displayed high confidence in teaching some of the content topics such as fractions, decimals, percentages, histograms and pie charts, patterns and measurements; however, their confidence was lower with respect to teaching aspects requiring connections between mathematics and statistics to other learning areas. The teachers also expressed lower confidence about engaging in critical debate about mathematical and statistical statements in social media. The findings further indicated that teachers' confidence was higher in teaching mathematics than statistics topics. This may be due to the fact that statistics is a new subject as it was introduced in C2005 (North & Zewotir, 2006) and many teachers are not yet aware of it.

In relation to their beliefs, teachers reported a positive view towards the need to be mathematically and statistically literate in everyday life, as well as in their teaching practices in general. The study also found that teachers' confidence and their beliefs were correlated with each other. It is recommended that teacher in-service programmes should provide opportunities for teachers to engage in activities which require critical examination of the ways in which mathematics and statistics are used in media. Besides, the findings revealed that socio-demographic factors such as gender, using curriculum, and attending workshops were mostly related to teachers' confidence.

Hence, male teachers were more likely to express a high confidence than female teachers. Teachers who use curriculum and who participated in various mathematics workshops were more likely to be confident in teaching a variety of mathematics and statistics topics. In addition, I found that the teachers who used technology in teaching and learning mathematics and statistics more frequently were more confident about their teaching of mathematics and statistics topics than those who never or rarely used technology. This supports other findings that using technology increases confidence (Spector, 2015; Yang, 2013).

10.1.7 In what way do teachers integrate curriculum to enhance mathematics and statistics understanding?

The study also explored how teachers use or consult curriculum in teaching mathematics and statistics concepts. Using open-ended questions, teachers were requested to indicate their level of familiarity with the NCS. Secondly, they were asked

about the ways in which curriculum guides them in their teaching. The findings showed that 14 (18.6%) teachers did not report any way in terms of working across the curriculum, 10 (13.3%) reported undefined or unrelated ways to the question, 11 (14.7%) teachers mentioned suggestions related to vertical alignment, 13 (17.3%) teachers reported suggestions related to horizontal curriculum alignment and 7 (9.3%) teachers reported the strategies related to making links to real life. Others suggestions were descriptions of other teaching strategies, consulting textbooks and other documents which were characterized by misunderstanding of the question.

Generally, the findings showed that most of the teachers (67%) reported a single way in which the curriculum was used, while 19% of the teachers were unable to provide clear descriptions, thus suggesting that they had little idea about how they could integrate the curriculum in mathematics teaching and learning. Some teachers explained that they received direction from the curriculum in terms of giving clear explanations, providing practical examples and outlining learner-centred methods in mathematics and statistics teaching and learning. These suggestions show that teachers' use of the curriculum needs improvement.

10.1.8 To what extent do the teachers integrate technology in their teaching of mathematics and statistics?

The study also investigated how KwaZulu-Natal mathematics teachers use, have access to, and integrate technology in the teaching and learning of mathematics. Various scholars agree that technology can be used as a tool that can facilitate teaching and learning and contribute to learners' achievement (Tishkovskaya & Lancaster, 2012, Moore, 2012, DoE, 2007, 2016). In order to examine their level of technology, teachers were requested to respond whether they use calculators, computers and the internet when they teach these topics, using closed questions. Similarly, teachers were required to rate their level of using technology to drill and practice, demonstrate statistics principles, solve and compute statistical problems, take a quiz etc., in teaching mathematics.

The findings showed that 84% of teachers from Grades 10–12 mostly used calculators, compared to 36.7% of teachers in Grades 4–9 who used them in teaching mathematics. On the other hand, only 40.0% of teachers who were teaching in Grades 10–12 reported that they used computers in mathematics and statistics teaching and learning, whereas 10.0% of teachers in Grades 4–9 reported that they used

computers in the classroom. These findings show that the technology used most commonly by the group for teaching mathematics is calculators. Almost all the teachers reported that they never use computers in their teaching of mathematics. Although the teachers reported that they do not use computers in teaching and learning, 60 (80%) teachers conveyed a positive view that using technology improves learners' understanding of mathematics. Only 19 (25.3%) teachers reported that they use the internet for education instructional practices. Furthermore, the findings showed that a few teachers sometimes use technology for educational practice. Globally, these findings indicate that teachers are not yet familiar with technology use.

10.1.9 Is there any relationship between demographic factors and the use of technology in instructional practice?

Even though technology is not yet developed among these teachers. I explored whether it could influence teachers' demographic factors on the use of technology. The comparison of means (a standard test used to compare differences between means of two or more groups) was used to identify factors associated with teachers' tendency to integrate technology into their teaching practices, at significant level $\alpha=0.05$. The findings showed that using technology was associated to the level of education, quintile school, gender, experience and attending mathematics workshop (P -values <0.05). The study also showed that teachers who have access to internet instructional resources have higher levels of confidence in teaching mathematics and hold broader beliefs about the nature of mathematics and the aims of teaching mathematics than teachers who do not use the internet for instructional purposes.

10.2 Research question 2: What it is the nature of teachers' proportional reasoning?

In this research question, I provide the findings related to teachers' level of proportional reasoning in solving four proportional tasks, explore the factors associated with teachers' proportional reasoning, and then test whether there appears to be a statistical significant relationship between teachers' proportional reasoning and their confidence in teaching mathematics and statistics topics, and beliefs about using mathematics and statistics in everyday situations.

10.2.1 What levels of proportional reasoning are revealed by teachers' responses to tasks based on fractions and percentages?

This study further measured the level of teachers' proportional reasoning in solving four proportional tasks. Two tasks were related to fractions and other two tasks were related to percentages. These tasks are discussed in chapter VIII. Teachers were encouraged to freely provide the answers to these problems and to explain/justify them by giving a detailed approach used to get to the answer. Teachers' answers were coded hierarchically according to their degree of appropriateness. The findings from teachers' answers showed that only 10 (20 %) responses were judged appropriate for the problem of smoking and lung disease. Table 8.1 indicates that approximately 35 (50%) teachers managed to make reference to the whole for the problem of Mary and John and pie chart, whereas 52 (69%) demonstrated an appropriate reasoning in solving the problem of finding 90% of 40.

These findings show that teachers' proportional reasoning needs improvement as the overall result shows that only 33 (44%) managed to respond to the problems correctly and 42 (56%) provided inappropriate answers to these problems. Teachers encountered various misconceptions when they solved these tasks. Some of them failed to make reference to the whole (for instance, to show when $\frac{1}{4}$ is greater than $\frac{1}{2}$ and to respond whether smoking causes lung disease in the given example). It was further found that teachers had misconceptions in finding the % of a fraction and $x\%$ of a number (x denotes any natural number).

10.2.3 Is there any relationship between teachers' proportional reasoning and their confidence in their ability to use mathematics and statistics in everyday life?

As discussed in chapter VIII, being numerate depends on someone's content knowledge. It is, therefore, understandable that teachers with proportional reasoning would demonstrate a high ability in solving problems related to mathematics in everyday situations. Teachers with understanding of proportional reasoning would become confident in teaching the topics related. The study used chi-square test of independence to explore the relationship between proportional reasoning and teachers' confidence about using mathematics and statistics in everyday life as well as their confidence in teaching mathematics and statistics concepts. This test helped to test whether teachers' proportional reasoning and their confidence about using

mathematics and statistics in everyday life, are independent, i.e. there is no relationship between them.

The findings revealed that proportional reasoning is related to teachers' confidence about using mathematics and statistics in everyday life (H_0 rejected, cfr. Table 5). It also showed that teachers' proportional reasoning is related to their confidence in their ability to teach a variety of mathematics and statistics concepts (H_0 rejected, cfr. Table 6). These findings indicate that proportional reasoning enables both teachers and students to act mathematically or statistically in everyday life and provides them with the capacity to teach mathematics topics.

10.3 Research question 3: What are the suggestions made by mathematics teachers with respect to improving the teaching and learning of mathematics and statistics concepts?

Improving the quality of teaching mathematics and statistics would be one of the goals that mathematics teachers should focus on. This study examined what teachers think they could do to improve maths and stats teaching and learning. In order to respond to this research question, teachers were requested to respond in closed and open-ended questions their strategies and plans about how they would go about improving the teaching and learning of mathematics and statistics (data handling) amongst learners in Grade 4 and above. After coding teachers' answers qualitatively, the findings revealed that teachers were most concerned with improving the motivation and interest of their learners for improving maths (45 or 33.1% cases) and stats (28 or 23.7% cases) teaching and learning. The second highest category encompassed suggestions about teacher explanations, advance preparation, going back to basics and providing more opportunities for practice for improving mathematics (34 or 25.0% cases) and statistics (28 or 23.7% cases). Further suggestions were the use of practical activities and concrete examples for improving maths (19 or 14% cases) and stats (15 or 12.7% cases), links to real life settings for improving maths (20 or 17.0% cases) and stats (20 or 17.0% cases) as well as investigations and data handling projects for improving maths (5 or 3.7% cases) and stats (15 or 12.7% cases). Moreover, teachers' answers were quantified into single and multiple strategies about improving maths and stats teaching and learning. The findings showed that most teachers suggested a single strategy 41 (54.7%) whereas

34 (45.3%) teachers reported more one strategy in terms of improving mathematics teaching and learning. Similarly, 40 (53.3%) teachers reported a single strategy whereas 35 (46.7%) teachers reported more than one in terms of improving statistics teaching and learning.

The teachers were also introspective about their own development and made suggestions regarding their own teaching approaches. They said that they needed to attend more workshops in order to improve their methodology of teaching mathematics and statistics. They commented that these workshops would help them to use modern methods since statistics especially was mentioned as being taught by traditional methods in South African schools and that teachers teach it using the way they had been taught (North & Zewotir, 2006). In addition, I investigated whether there appear to be certain factors which influence teachers' willingness to mention multiple strategies. Although I looked at the difference between mentioned multiple or a single strategy, it was noted that some teachers do believe that multiple strategies should be used in the teaching and learning of statistics, but are not aware of a variety of strategies to do so due to a lack of professional development.

10.4 Research question 4. Is there any relationship between teachers' demographic factors and their

- a) *Their teaching methods and assessments strategies*
- b) *Their confidence and beliefs*
- c) *Their use of technology*
- d) *Their use of curriculum*
- e) *Their proportional reasoning*
- f) *The strategies they suggested for improving the mathematics and statistics teaching and learning*

10.4.1 Relationship between demographic factors of the teachers' profiles and the methods they use for teaching and assessment.

Since the participants have various characteristics, it is understood that their teaching practices are not similar, and of course there is a variation between teachers' demographic groups. For instance, do experienced and non-experienced teachers use technology in the same way? In order to explore the factors associated to the

teaching methods, binary logistic regression was used at the significant level $\alpha=0.05$. The findings revealed that teaching methods are associated to gender and level of education ($p\text{-value}<0.05$). I found that male teachers and teachers who attended postgraduate diploma courses in education are more likely to use a variety of methods compared to females and teachers who did not attend postgraduate diploma courses. Besides, assessment strategies are associated to age, teaching experience, attending mathematics workshop and using curriculum ($p\text{-value}<0.05$).

Besides young and less experienced teachers, those who attended mathematics workshops and those who use curriculum are more likely to use a variety of assessments than older and experienced teachers, those who did not attend workshops and those who do not use the curriculum respectively. This finding is surprising as some studies showed that as teachers become experienced, they produce effective learning. However, some previous studies found similar results. For instance, Sahinkarakas (2012) found that inexperienced teachers were aware of the positive effects of formative assessment on learning process.

10.4.2 Is there any relationship between teachers' confidence and beliefs and their demographic factors?

I also explored the factors which may contribute to confidence building. The findings revealed that there appears a statistical significant relationship between teachers' confidence in their ability was significantly different by gender ($p\text{-value} = 0.000$), their age ($p\text{-value} = 0.000$), their use of the NCS ($p\text{-value} = 0.001$), where the teachers who used and were trained on the NCS expressed a high confidence in teaching fractions, decimals, percentages and measurements than teachers who did not use it.

I also found a significant relationship teachers' confidence in their ability and using technology in teaching ($p\text{-value} = 0.034$), where the teachers who use technology in teaching mathematics and statistics were more confident than those who do not use it. In addition, old teachers were more positive for the beliefs concerning their towards mathematics and statistics. For instance, they expressed an agreement that "statistical literacy, thinking and reasoning is an extremely important skill to develop in everyday life, they demonstrate the need to be mathematical numerate to be an intelligent consumer and they believe numeracy is becoming increasingly important in our society" ($p\text{-value} = 0.000$). The older teachers further expressed a

disagreement that it is difficult to teach statistics both conceptually and procedurally (p-value=0.002).

10.4.3 Relationship between teachers' use of technology and their demographic factors?

The findings showed that gender, level of study, teaching experience, attending workshops and school quintile may influence teachers to use technology in different instructional practices (p-value<0.05). However, analysis showed that the difference between groups in terms of using technology has a moderate practical significance effect. This means that young teachers do not show a very high ability in using technology than old teachers. Similarly, there is no big difference in using technology between those who attend workshops and those who do not attend these workshops. Furthermore, there is no very big difference between experienced teachers and non-experienced teachers, or those who attended postgraduate courses and those who did not attend them.

10.4.4 Is there any relationship between teachers' use of NCS-Grade R-12 and their demographic factors?

The study also examined the factors which may influence teachers to use curriculum. The findings showed that teachers aged > 40 years old are more likely to use the curriculum document compared to young teachers (p-value = 0.009, OR = .084). A further significant finding is associated to teachers' participation in professional development activities. The findings showed that teachers attended previous mathematics workshops, are more likely to use the curriculum (p-value = 0.001, OR = 0.078). Furthermore, teachers who met with a local group of teachers to study and discuss mathematics and statistics teaching on a regular basis, are more likely to use the curriculum than those who did not (p-value = 0.026, OR = 0.165). This indicates that, apart from teachers' age, the attendances of professional development courses are very important in assisting teachers to use curriculum issues.

10.4.5 Is there any relationship between teachers' proportional reasoning and their demographic factors?

I further explored whether there is a variation of teachers' understanding according to teachers' categories of age, gender, level of education and teaching experience. Using logistic regression, I examined whether some of these factors

influence teachers' proportional reasoning. The proportional reasoning model was fitted using gender, attending workshop, level of education, teaching experience and using curriculum. The findings showed that there is a statistical significant difference between teachers' proportional reasoning and gender (p-value=.027, OR=.219), teaching experience (p-value=.003, OR=.152), and using curriculum (p-value=.021, OR=.214). The study suggested that teachers should attend professional courses in order to improve their proportional reasoning. It would be important also for teachers to use curriculum as the way of improving their proportional reasoning, since curriculum provides the content to be taught and the ways to teach that content.

10.4.6 How do factors related to age, gender, teaching experience, and knowledge of curriculum and levels of study influence the strategies mentioned?

Binary logistic regression was used to model teachers' suggestions and teachers' demographic factors, given that the response variable is dichotomous. The findings revealed that teachers' strategies about improving mathematics teaching and understanding are associated to gender, level of education, age and the use of curriculum (P-value<0.05). Moreover, the findings showed that teachers' strategies about improving statistics teaching and learning are associated to the attendance of mathematics workshops, age and level of education (P-value<0.05). The study suggests that as teachers attain a higher level of education, use curriculum and attend mathematics workshops they improve their level of thinking about developing teaching and learning. The study suggests that there is a variation in the interests and needs of the teachers, which must be acknowledged by professional development agencies. Teachers have their own personal trajectories of development initiated by their experiences, successes, fears, hopes and perceptions. However, they also revealed and emphasised many common concerns which must be taken into account in future offerings of the programme and should also be noted by education authorities in South Africa.

Briefly, the findings revealed that attending mathematical or statistical workshops has a positive impact in using multiple assessments, integrating curriculum, using technology and developing their confidence. Apart from attending maths workshops, the findings revealed that teachers who met with a local group of teachers to study and discuss mathematics and statistics teaching on a regular basis (another form of

professional learning) were more likely to use curriculum. Teachers are recommended to attend different professional courses as the way of improving their teaching practices.

Teachers' age was found to be associated with their teaching practices. I found that young teachers (≤ 40 year old) were more likely to use different teaching methods and assessment strategies and suggest various strategies in teaching mathematics and statistics. However, these young teachers reported that they do not use the curriculum as it should be used.

Postgraduate studies in education was further found to be related to teaching practices. The findings indicated that teachers who attended postgraduate courses were more likely to use multiple teaching methods, suggest multiple strategies to improve statistics teaching and learning, use curriculum, and use technology than teachers who did not attend these. Professional learning was also found to be related to the use of multiple strategies in improving statistics teaching and learning, developing teachers in getting familiar with the curriculum and using multiple assessments to enhance mathematics and statistics teaching and learning.

Furthermore, teaching experience was found to be related to teachers' content knowledge in solving proportional tasks. I found that experienced teachers were more likely to respond to the tasks appropriately than non-experienced teachers even though it was found that older teachers focus more on the use of single assessment strategy than younger teachers. On the other hand, non-experienced teachers were found to be more likely to use multiple assessment strategies and technology in teaching mathematics and statistics than experienced teachers. This controversial teaching experience was discussed by Kini and Podolsky (2016) who agree that not every inexperienced teacher is less effective and not every experienced teacher is more effective.

In addition, gender was found to be related to teaching practices. The analysis showed that male teachers were more likely to express multiple teaching methods and use technology in teaching mathematics, than female teachers. Male teachers also expressed a high confidence in teaching a variety of mathematics and statistics topics than female teachers. However, in terms of how teaching and learning could be improved, female teachers were more likely to suggest multiple strategies in terms of improving mathematics teaching and learning than male teachers.

What can be further noted from these results is that teachers struggled to link mathematics to real life. For instance some findings from Sections 10.1.6 and 10.2 , are similar. On the one hand, in Section 10.1.6 teachers expressed a low confidence in linking mathematics and statistics to other learning areas as well as engaging in critical debate about mathematical and statistical statements in social media. On the other hand, in Section 10.2 they struggle to solve fractions and percentages applied to real life. These findings suggest that teachers should try to extend their teaching by involving the problems related to real life. Thus, students will understand the role that mathematics plays in our everyday life.

Please note that the findings presented in this study, cannot be generalised to the whole population of KZN mathematics teachers as I have only worked with 75 teachers coming from KZN rural areas. The findings for other studies can differ from these presented in this study.

CHAPTER XI. CONCLUSION

11.1 General Findings

The goal of this research was to explore teachers' practices, confidence and beliefs in teaching mathematics and statistics topics in KwaZulu-Natal schools.

I believe that the study responded to the main research questions posed above. The study brought a new insight in terms of reminding teachers that they must take into account the importance of learning objectives, think about the new strategies of introducing a topic in the classroom, refute traditions and undertake modern teaching methods and assessment strategies in teaching and assessing mathematics and statistics. This study also reminds teachers that using curriculum would be another way to improve their teaching and learning and also prompts teachers that using technology, especially the internet, would help them to use a variety of teaching methods and assessments and new approaches to teaching maths and stats concepts. The study also reminds teachers to link teaching mathematics and statistics to real life as the best way to have understanding of why learners must learn them. The study further revealed that a strong focus about improving mathematics and statistics teaching and learning would be put into increasing motivation and interest of learners, using practical activities and concrete examples, making links to real life settings, using investigations and data handling projects. In addition, this study showed that teaching practices differ from one teacher to another. There is variability in teaching practices according to teachers' demographic factors such as gender, age, teaching experiences, attendance of workshop, level of education, etc.

11.1 Recommendations

Although the study has reached its objectives and managed to respond to the research questions, some recommendations can be considered. In terms of setting lesson objectives the findings revealed that only half of the teachers have managed to set learning objectives appropriately. This is problematic, given that the lesson plan is the teacher's road map of what learners are supposed to learn. Teachers must know that if the objectives are clear, this will help them decide the types of teaching and

learning activities. The study reminds teachers to pay attention to teaching and assessments strategies which would help learners to improve the quality of learning. For instance, it suggests that teachers should focus on investigations and projects, real life examples, manipulative approaches, practical examples, classroom discussion, grouping and a learner-centred approach to increase learners' enthusiasm in learning mathematics and statistics.

In teaching statistics, teachers need to improve statistics teaching and learning by implementing innovative approaches such as integrating technology, investigations and cooperative learning approaches since they enable learners' understanding of statistics. This study suggests that post graduate courses as well as professional workshops in teaching mathematics and statistics should be supported to help teachers strengthen their content knowledge and pedagogy skills. These professional courses assist teachers to improve their existing practices. Teachers are further advised to consult the internet and use computers when they teach and learn mathematics and statistics. In addition, I found that teachers rarely integrate curriculum in teaching and learning mathematics and statistics. They need to know that curriculum is the core of all teaching processes since it provides teachers with both content and pedagogical skills. The study provides evidence that students' achievement is promoted by effective teachers who perform their work of teaching well, while poor teachers lead students' dissatisfaction (Anthony & Walshaw, 2009).

In order to encourage teachers to attend more professional development programmes, these should ideally be carried out at the places where teachers work, so that they can learn while they practice and can be supported as they try to implement more progressive teaching methods. Through the professional development support programmes, teachers can be given practical advice on how to teach in groups in order to share experiences and knowledge, how to increase classroom discussions which bring clarification, as well as how to design and assess projects using real data so that they start using mathematics and statistics to solve problems in real life. The use of these methods can improve learners' critical thinking, reasoning, self-discovery and investigation skills. These different approaches will enable learners to look at different ways of finding solutions to mathematical and statistical tasks.

However, it was also mentioned that rural schools still lack schooling materials such as electricity, computers and libraries (Gardiner, 2008), and those factors may

also reduce teaching quality or professional development of school educators in these areas. In this regard the need in terms of improving the quality and functionality of education which is still causing the lowest level of literacy and numeracy was pointed out (Modisaotsile, 2012).

As South Africa is an emerging resource economy, there is an urgent need to increase the number of mathematically proficient learners who enter the economy each year, which means that mathematics teachers' teaching and assessment practices need to be made more effective. It is believed that this study has identified particular areas where teachers' teaching and assessment practices can be improved, as well as factors which are associated with progressive practices. Therefore, appropriate support from professional development initiatives can help teachers move towards creating such classrooms.

I recommend that teacher development programmes should aim to improve teachers' confidence in connecting mathematics and statistics to other learning areas as well as highlighting the importance of learning mathematics and statistics using the mass media. Teachers who have a positive attitude about their role as teachers will help to inspire their learners to develop confidence in mathematics and statistics. The study recommends that teachers develop their level of proportional reasoning, and suggests that they continue to solve various mathematical tasks. This study brought a new insight with regards to teaching practices which should be considered in developing teaching and learning processes. For instance, teachers' plans and strategies to improve mathematics and statistics present various suggestions that can be involved in government policy for developing teaching and learning.

11. 2 Limitations of this study

Although the research has fulfilled its aims, there were some unavoidable limitations. Due to limited time and financial issues, I did not use popular sampling methods but I used teachers who were selected purposively by the Department of Basic Education (DOE) to attend maths4stats course in UKZN in 2015. Otherwise, I would have used other sampling methods like stratified random sampling so that the results of this study could be generalized to the whole country. One of the issues that could have been a limitation was the length of the questionnaire. Many of the teachers who were approached did not complete the questionnaire because they found it too long. Only 75 mathematics teachers managed to respond to it, while it was expected

that 136 teachers would respond. The length may have compromised teachers' responses as well, because they may have found it onerous to respond with the same diligence that they had at the beginning. The study was also limited to the use of questionnaires where mixed methods, were used. As mentioned at the beginning of this thesis, the study adopted the instrument developed by Beswick et al. (2012) who used questionnaires in their study. However, it would be interesting to include other data collection methods such as observation and interviews in order to strengthen the study by collecting diverse data. Due to the time limit, the study did not go further about how teachers would intervene about teaching the four tasks discussed in Chapter VIII, as well as the connection between proportional reasoning and their PCK.

11. 3 Reflections on the Theoretical Framework

In this study, statistics had been taken into consideration given that all mathematics also teach statistics. This study extended the framework of Beswick et al. (2012) because it has some limitations. Beswick et al. used the framework of Shulman (1987), Ball et al.(2008) and added confidence and beliefs and explored the nature and development of middle schools 'mathematics teachers' knowledge. In this study, I explored teachers 'practices in teaching mathematics and statistics in Grades 4-12. This means that I used teachers who were teaching in primary and secondary schools. For this reason, I included the framework of Burgess (2009) and one of Koehler and Mishra (2009) because those teachers teach both mathematics and statistics and use technology in classroom discourse. Moreover, I included the framework of Burgess (2009) because teaching statistics requires knowledge of statistics and pedagogy, and the framework of Koehler and Mishra (2009) because technology was claimed as tool that assesses teaching and learning. The use of these frameworks, showed that teaching both mathematics and statistics, requires one to have not only mathematics knowledge but also statistics knowledge, knowledge of technology and confidence and beliefs towards mathematics and statistics.

11. 4 Suggestions for further studies

This study opens a way for future researchers who might be interested in examining middle schools teachers' practices, confidence and beliefs in teaching mathematics and statistics topics using the instrument developed by Beswick et al. (2012). The following can be addressed in future research. It would be useful to examine teachers' PCK by examining how teachers would intervene about teaching four mathematical tasks discussed in chapter VIII. In our future research, I plan to address this inconvenience.

In chapter III, I explored teachers' teaching and assessment strategies that they use in teaching mathematics and statistics. IN terms of future work, it would be interesting to observe teachers in their schools. In chapter V, I explored teachers' strategies and plans about how they would improve teaching and learning. An important aspect that can add insight to the findings would be to explore learners' suggestions about improving mathematics and statistics teaching and learning in future studies. In chapter VIII I found that teachers demonstrated a high confidence in teaching percentages and fractions according to their level of rating. It would be interesting to visit teachers in their classroom to confirm whether there is a relationship between what they wrote and what they do in the classroom. In chapter IX, I explored teachers' use of technology in teaching mathematics and statistics. It would be worthwhile to conduct a study about teachers' beliefs towards technology in teaching mathematics and statistics. It would be interesting to investigate whether learners also believe that technology is one of the factors that contribute to their achievement.

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Section 2: Preparing to teach a concept in mathematics (numeracy) and statistics (literacy)

If you were planning to teach a concept from your mathematics or statistics program, how would you go about teaching it? Choose a concept that you think is important, for example: percentage, measurement, mental computation, ratio, fractions, algebra, data types, surveys, questionnaires, populations and samples, tally table, frequency, pictograms, bar graphs, pie graph, histogram, scatterplot, grouping data, mean, median, mode, range, stem and leaf plot, random experiment, events: (certain, uncertain, impossible), frequency, probability, chance etc. Briefly outline how you might design and teach a unit for your chosen topic to develop an understanding with your learners.

- 1 Concept (chose one concept).....
- 2 Understanding objective(s) of the concept to be taught.....
- 3 I would introduce the concept by.....
- 4 Class time I would spend on this concept:.....
- 5 Teaching methods and grouping, I would include:.....
- 6 Assessment methods and strategies, I would include:.....
- 7 Have you ever taught this concept before? Yes.....No.....
- 8 Do you enjoy teaching this concept? Yes.....No.....
- 9 My learners generally respond to this concept by:.....
- 10 How could you work across the curriculum in order to contribute to learners' understanding of this concept?

Section 3. Your teaching practices

How would you go about improving the understanding of Mathematics and Statistics (Data Handling) amongst learners in grade 4 and up? Please state the main goals, plans and strategies that you would use and why (ex. I would improve students' interest in mathematics, because it makes them very nervous about learning it).

- 1a) To improve the learning and understanding of Mathematics, I would:
- 1b) I would do this because:.....
- 2a) To improve the learning and understanding of Statistics (Data Handling), I would:
- 2b) I would do this because:.....

Section 4: Confidence

Listed below are some of the concepts that are included in the curriculum and are considered to contribute to “Being numerate “ and “Being literate”, i.e. to have mathematical and statistical understanding, thinking and reasoning.

Please mark your **level of confidence** in your ability to develop and understanding of listed items amongst the learners in the class that you teach. *Please rate on a scale (1= very low, 2= low,3=moderate, 3= high and 5=very high)*

Topics		Low	Moderate	High
CN1	Fractions			
CN2	Decimals			
CN3	Percentages			
CN4	Ratios and proportions			
CN5	Measurement (Length, area, weight, volume, temperature, speed and time)			
CN6	Presenting mathematics in an expository style (detailed explanation)			
CN7	Pattern and algebra			
CN8	Mental computation			
C9	Connecting mathematics to other key learning areas			
CN10	Critical debate on mathematics and statistics in the media (newspapers, TV, internet,...)			
CN 11	Pie graphs and histograms			
CN 12	Simple probabilities understanding and calculations			

CN 13	Range and variations
CN 14	Inference and prediction
CN 15	Connecting statistics to other key learning areas
CN16	Ideas of Sampling and data collection
CN 17	Using statistics out-of the class room situation

Section 5: Mathematics/Statistics and numeracy/literacy in everyday life

Listed below are some statements concerning beliefs or attitudes about being numerate (understanding numbers)

and being statistically literate. Please mark your level of agreement with each statement. **Please rate on a scale of 1 to 3**

(1= disagree, 2=neutral (undecided) and 3 = agree).

Items	Indicate your level of numeracy and literacy in everyday life		
	Disagree	Neutral	agree
EL1 I need to be mathematical numerate to be an intelligent consumer			
EL2 I am confident that I could work out how many tiles I would need to tile my bathroom			
EL3 I often perform mental calculations in my head (without a calculator)			
EL 4 I believe numeracy is becoming increasingly important in our society			
EL 5 I believe numbers and how to work with them is as essential for everyone as reading and writing are			
EL 6 I believe knowledge of data types, surveys, population, samples, frequency, plots, grouping data, mean, median, mode, random experiment, probability, etc. is becoming increasingly important in our society			
EL 7 I have difficulty in identifying mathematics structures (forms) in everyday situations			
EL 8 Proportional reasoning is needed to understand claims made in media (newspapers, TV, internet, magazines, radio)			

- EL 9 I have difficulty in understanding statistical facts in everyday situations
- EL 10 Given the price per square metre, I could estimate how much it would cost to carpet the lounge
- EL 11 Mathematics/statistics is not always communicated well in newspapers and in the media
- EL 12 I often use mathematics/statistics to make decisions and choices in everyday life
- EL 13 I can easily extract information from tables, plans and graphs
- EL 14 Statistical literacy, thinking and reasoning is an extremely important skill to develop in everyday life

Section 6. Numeracy and literacy in the classroom

Listed below are some statements about Mathematics and Statistics concerning beliefs or attitudes about being numerate in relation to teaching and learning. **Please rate on a scale of 1 to 5 your level of agreement (1=strongly disagree,2=disagree,3=neutrality, 4=agree and 5=strongly agree)**

Items	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
NC1 Mathematics is just computations					
NC2 I would feel uncomfortable if a child suggested a solution to a mathematics problem that I hadn't thought of previously					
NC3 Teachers of mathematics should be fascinated with how learners think and be intrigued (interested) by alternative ideas					
NC4 Telling learners the answer is an efficient way of facilitating their mathematics learning					
NC5 Allowing a child to struggle with mathematics problems, even a little tension, can be necessary for learning to occur					
NC6 Mathematical content is best presented in an expository style: demonstrating, explaining and describing concepts and skills					

NC7	It is important that mathematics content is presented in the correct sequence					
NC8	Ignoring the mathematics ideas that children generate themselves can seriously limit their learning					
NC9	Justifying the mathematical statements that a learner makes is an extremely important part of learning the subject.					
NC10	Effective mathematics teachers enjoy learning and doing mathematics themselves.					
NC11	It is difficult to teach mathematics without a text book					
NC12	Mathematics teaching should assist learners to develop an attitude of inquiry (asking questions, being curious about solutions)					
NC13	Mathematics in high school is best taught in mixed groups of abilities, at least until grade 9					
NC14	Often the mathematics work I do in the classroom is not relevant to the students' everyday lives					
NC15	I use technology to assess mathematics learning (computers, calculators)					
NC 16	Teachers of mathematics should be knowledgeable of the way children think and be intrigued (interested) by alternative ideas					
NC 17	Statistics is just computations					
NC 18	I would feel uncomfortable if a child suggested a solution to a statistics problem that I hadn't thought of previously					
NC 19	Effective mathematics teachers enjoy learning and doing statistics themselves					
NC 20	It is difficult to teach statistics without a text book					
NC 21	Statistics teaching should assist learners to develop an attitude of inquiry (asking questions, being curious about solutions)					

NC 22	Often the statistics work I do in the classroom is not relevant to the students' everyday lives				
NC 23	Teaching statistics should be knowledgeable by the way children think and be intrigued (interested) by alternative ideas				
NC 24	Statistics teaching should assist learners to develop a positive attitude to problem solving				
NC 25	Statistical literacy, thinking and reasoning are the main goals in statistical teaching and learning				
NC 26	Statistical material is best presented in an expository style: demonstrating, explaining and describing concepts and skills				
NC 27	It is difficult to teach both statistics conceptual and procedural				
NC28	Using technology helps increasing learners' learning and understanding statistics				

Section 7: Student survey items

Item 1

Mary and John both receive pocket money. Mary spends $\frac{1}{4}$ of hers and John spends $\frac{1}{2}$ of his.

1).Is it possible for Mary to have spent more than John?

2). Why do you think this? Explain
.....

3). What responses would you expect from your students? Write down some appropriate (suitable) and inappropriate (unfitting) Response (use * to show appropriate responses)
.....

4) How would /could you use this item in the classroom? For example, choose one of the inappropriate responses and explain how you would intervene.

Item 2

1) What is 90% of 40?

Please explain your reasoning.

2) What responses would you expect from your students? Write down (or list) some appropriate and inappropriate responses (use * to show appropriate responses)

3) How would /could you use this item in the classroom? For example, choose one of the inappropriate responses and explain how you would intervene.....

Item 3

Consider the following problem that learners were asked in a survey about chance and data:

The following information is from a survey about smoking and lung disease among 250 people.

	Lung disease	No lung disease	Total
Smoking	90	60	150
No smoking	60	40	100
Total	150	100	250

1) Using this information, do you think that for this sample of people, lung disease is affected by smoking? Explain your answer.

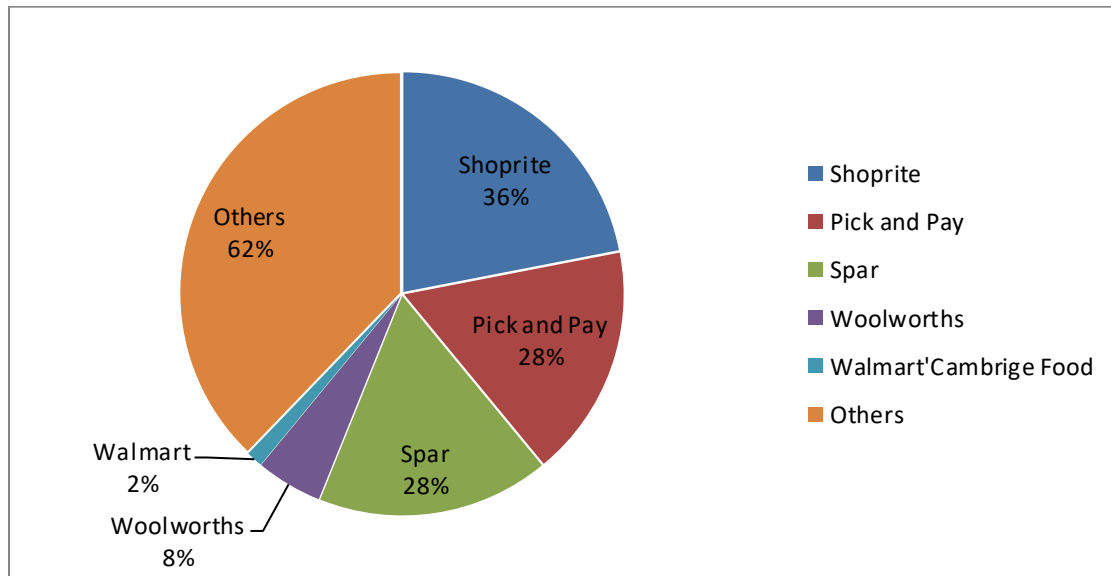
2) Consider each of the following answers and explanations to the problem and discuss how you would respond to the answers
Student1: Yes, 90 people in the study who smoked got lung disease.....

Student2: No, since 60 people in the study were found to be "not smoking but have lung disease" and 60 people in the study were found to be "smoking but have no lung disease", so that the number of people in the study in these two groups mentioned are the same.....

- How would /could you use this item in the classroom? For example, choose one of the inappropriate responses and explain how you would intervene.....

Item 4. Consider the following graph

National wide retail grocery market shares (demonstration, not factual)



Shoprite	36%
Pick and Pay	28%
Spar	28%
Woolworths	8%
Walmart'Cambrige Food	2%
Others	62%

1) Explain the meaning of this pie chart.....

2) Is there anything unusual about it.

3) What responses would you expect from your students? Write down some appropriate and inappropriate responses (use * to show appropriate responses)

4) How would/could you use this item in the classroom? For example, choose one of the inappropriate responses and explain how you would intervene.

8. Questions related to professional learning

Q 8.1 Have you seen the following documents in your school?

Have you read parts of any of them?

Have you used any ideas from them in your classroom?

Have you trained on these documents?

Tick one box in each row

Items		Circle one option only in each line				
		Not seen	Seen	Read	Used	Trained
PL1	National Curriculum Statement (NCS)					
PL2	Maths Curriculum for South Africa Schools					
PL3	CAPS (Curriculum and Assessment Policy Statements) mathematics for South Africa Schools					
PL4	Key Intended Numeracy Outcomes					
PL5	Numerate Learners : Numerate Adults					
PL6	South Africa Curriculum Mathematics-Numeracy					
PL7	National Curriculum Statement Grades R-12 (2012).					

Q 8.2 In the past 3 years, have you participated in any of the following activities related to teaching mathematics and statistics? Tick one box in each row

Items	In the past 3years, have you			
	Maths		Stats	
	Yes	No	Yes	No
PL1 Observed other teachers teaching mathematics/statistics as part of your professional development (formal or informal).				
PL2 Met with a local group of teachers to study and discuss mathematics and statistics teaching on a regular basis				
PL3 Served as a mentor and/or peer coach in mathematics and statistics teaching, as part of a formal arrangement that is recognized or supported by the school or district. (Please do not include supervision of student teachers)				
PL4 Attended a workshop on mathematic/statistics teaching				
PL5 Received certification from PGDE ⁱ , NPDE ⁱⁱ and Honours				

Section 9. Questionnaires related to technology

**9.1 To what extend are the learners in your mathematics class permitted to use calculators during mathematic lessons?
(Tick one box in each row)**

T1 Unrestricted use Yes.....No.....

T2 If yes, do you use calculators to teach statistics? Yes.....No.....

T3 Are computers available at your schools? Yes.....No.....

If Yes, would use them for teaching mathematics and statistics in class Yes.....No.....

T4 Do any of the computers learners use have access to the internet? YesNo.....

T5 If yes, do you use the internet for instructional /educational purposes? YesNo.....

9.2 About how often do you, in statistics class, use computers to: *(Tick one box in each row)*

Items	Computers are used to				
	Never	Rarely	Sometimes	Often	Always
T6 Drill (exercise) and practice					
T7 Demonstrate statistics principles					
T8 Collect data using sensors or probes (collecting data using software)					
T9 Retrieve or exchange data					
T10 Solve and compute statistical problems					
T11 Take a test or quiz					

End

Thank you for your participation

ⁱ:Post Graduate Diploma in Education

ⁱⁱ:National Professional Diploma in Education