TEACHING STRATEGIES USED BY MATHEMATICS TEACHERS TO TEACH GRADE 6 PROBABILITY IN NKANGALA DISTRICT

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TEACHING STRATEGIES USED BY MATHEMATICS TEACHERS TO TEACH GRADE 6 PROBABILITY IN NKANGALA DISTRICT

by

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Submitted in partial fulfilment of the requirements for the degree in

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ABSTRACT

The importance of teaching and learning probability has been outlined in many articles and research studies. This study presents a model used by teachers in teaching probability to Grade 6 mathematics learners. Drawing on various sources, including the literature, theoretical framework, interviews, and lesson observations, the study explored strategies used by mathematics teachers to teach probability to these learners. The assumption made in this study is that the teachers do not have adequate content knowledge (CK) as well as pedagogical content knowledge (PCK) to successfully teach probability to Grade 6 learners.

The study employed a qualitative approach to understand the teachers' insight into teaching of probability to Grade 6 learners. The population of this study constituted of teachers from primary schools in different circuits in the Nkangala district in the Mpumalanga province, South Africa. Two instruments, interviews and observations, were used to collect data in this study. The theoretical framework for teacher knowledge and understanding of probability (Adapted from Kvantinsky & Even, 2002:1) served as a reference point for this study. Data were analysed using thematic analysis. The study communicates key findings, which were exemplified with explanations and specimens of typical teacher responses together with suggestions and recommendations.

The results indicate that the participating teachers used teaching and learning approaches such as cooperation, discussion, and problem based approaches to enforce essential aspects that enable learners' understanding of probability. Although the essential aspects were enforced, these teachers' knowledge on how to implement various teaching and learning approaches was limited. They relied heavily on conducting experiments and recording results.

Key words: Teaching strategies; mathematics; Grade 6; probability; teaching and learning approaches; essential aspects.

DECLARATION

I hereby declare that the following dissertation: Teaching strategies used by mathematics teachers to teach Grade 6 probability in Nkangala District is my own original work and has not previously been submitted to any other institution of higher learning, or been submitted for evaluation. All sources quoted in this document are indicated and acknowledged by means of a comprehensive list of references.

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DEDICATION

I dedicate this dissertation to my parents, Piet Mabuse and Violet Kgomotso Bokaba, who were my first teachers. They instilled me with their intelligence, energy for life, thirst for knowledge and love. I thank them for their unwavering support and I am grateful that I know where I come from.

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My deep and heartfelt gratitude goes to:

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- My Supervisor, Dr J.N Mwambakana and the co-supervisor, Dr J.J Botha for taking me through this journey. I appreciate your abundant patience and the dedication that you have shown.
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- My family**:**
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LIST OF ABBREVIATIONS

ABET	Adult and Basic Education and Training
ACE	Advance Certificate in Education
ANA	Annual National Assessment
AS	Assessment Standard
ATP	Annual teaching Plan
BED	Baccalaureus Educationis
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statement
CK	Content knowledge
CI	Curriculum Implementer
DBE	Department of Basic Education
ECD	Early Childhood Development
FET	Further Education and Training
GET	General Education and Training
GPLMS	Gauteng Primary Language and Mathematics Strategy
LO	Learning Outcome
NCS	National Curriculum Statement
NPA	National Protocol on Assessment
OBE	Outcomes-Based Education
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
RNCS	Revised National Curriculum Statement
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Education Quality

GLOSSARY

The terms below are described in the context of the study:

- **Teaching strategy:** This is regarded as any consideration made by teachers in their method of teaching to result in meaningful learning in the classroom.
- **Mathematics:** This is one the subjects that forms part of the curriculum in South Africa's education system. It is compulsory in the GET phase and contributes towards the learners' progression from one grade to the other.
- **Grade 6:** The exit grade in the Intermediate Phase
- **Probability:** A mathematical concept that deals with chance or uncertainties. A field in mathematics that deals with chance. Children learn more on how to conduct experiments and predict what could happen in future.
- **Teaching and learning approaches:** These are the techniques used by teachers in the teaching of mathematics in order for learning to result in the construction of new knowledge, for example, teaching using computers is one of the strategies that could be used in the classroom.
- **Essential aspects:** These are key features that describe the nature of probability. These should be evident when a lesson on probability is presented (cf. section 2.5.4).
- **Discussion:** This is an integral teaching and learning approach that serves as the vehicle for implementing other teaching approaches or strategies.
- **Effective teaching:** refers to the use of techniques that best serve the learning needs of learners (cf. table 2.1; section 2.4.3; Ko & Sammons, 2013).
- **Appropriate teaching strategies:** refers to teaching that helps to activate students' curiosity about a class topic, engage students in learning, develop critical thinking skills, keep students on task, engender

sustained and useful classroom interaction, and, in general, enable and enhance the learning of course content (Boundless Education, 2013).

- **Categories:** Elements or items that constitute the themes that were used to analyse data.
- **Enforce:** This refers to how a particular practice in a teaching and learning situation was implemented with the aim of achieving lesson objectives.
- **Guiding Principles:** These are the guidelines on how a particular teaching approach could be implemented during the lesson presentation (cf. table 2.4; section 2.7).

CHAPTER 1: INTRODUCTION AND OVERVIEW

The South African Curriculum aims to ensure that learners acquire and apply knowledge and skills in ways that are meaningful to their own lives (Department of Basic Education [henceforth, the DBE], 2011a, p. 4). To acquire these, teachers should ensure that they use a variety of methods and techniques to improve the quality of their teaching of mathematics.

Malan, Ndlovu and Engelbrecht (2014, p.3) indicate that if contextual problem-based learning is integrated into the curriculum, then students' learning pattern will be influenced in a favourable direction. This is one of the teaching approaches that teachers could use to make learning meaningful and to lead to the construction of new knowledge. This would be possible if teachers made their lessons learner-centred. As such, the success of the lesson depends on the role of the teacher in the teaching and learning situation.

In this study, I explored the teaching strategies used by teachers to teach probability to Grade 6 learners. This was done in an attempt to describe, understand, and analyse how the quality of teachers' practice could be improved, particularly in relation to how essential aspects are enforced. The focus of this study also included how appropriate strategies and guiding principles are implemented in teaching probability. This chapter presents the background of the study; rationale for the study; problem statement; research questions; importance of the study; methodological considerations; limitations, and the outline and organisation of each chapter.

1.1. BACKGROUND OF THIS STUDY

As part of the curriculum reform process in South Africa, a new assessment strategy in Grade 6 (the exit level for the Intermediate Phase) was introduced by the DBE in 2008. This assessment is called the Annual National Assessment (ANA), which aims to track learner performance each year in Grades 3, 6 and 9 in language and mathematics (DBE, 2011a, p.5).

It was further indicated that the ANA results would be used to monitor learner progress, guide teacher planning and distribute resources in order to improve the language and mathematics knowledge and skills of learners in the grades concerned. Most importantly, ANA provides teachers with essential data about the baseline language and mathematics capabilities of learners at the beginning of each grade, and thereby helps teachers to make informed decisions when planning the year's specific programme.

Learners in Grade 6 wrote nationally set ANA papers in 2008, 2009, 2011, 2012, 2013, and 2014 at the end of Term 3. The results were officially published and analysed in the Diagnostic Reports to inform all levels of the education system about areas where learners experience challenges and, in turn, provide suggested interventions to address these areas (DBE, 2013, p.6).

The departmental directive of the provincial office was that each district in a province should choose 10 schools that would be moderated externally. The Nkangala District, one of the four districts in the Mpumalanga province, comprises four sub-districts, each of which has five circuits. Each circuit has an average of 16 primary schools. The selection for moderation was based on learner performance and was carried out as follows: 5 schools were selected from each sub-district. From each school, 10 scripts were sampled as follows: 4 scripts from the category of high achievers, 3 scripts from the category of average achievers and 3 scripts from the category of underachievers. In total, 200 scripts were selected for external moderation at district level.

Schools were requested to moderate all scripts (to conduct school-based moderation) before submission for external moderation by district officials. Heads of Departments in schools and Curriculum Implementers (district subject advisors) had an opportunity to moderate the selected scripts.

1.2. RATIONALE FOR THIS STUDY

As the researcher, my experience as a Curriculum Implementer (CI) and district moderator brought to my attention the dilemma regarding the poor performance of Grade 6 learners in mathematics in general. In particular, I realised that learners experience challenges in answering questions based on the field of probability.

The diagnostic report on ANA also indicated that “Probability is one of the most misunderstood concepts by learners who are in Grade 6” (DBE, 2012, p.22). Makina and Wessels (2009, p.56) indicate that “the introduction of Probability in the secondary South African curriculum needs a serious reconsideration of the way it is taught to the learners.” The teaching of probability therefore prompts the need for developing teaching strategies that promote the effective teaching and learning of mathematics in general, and in the field of probability in particular.

In 2012, 2013, and 2014, the ANA scripts for Grade 6 learners were remarked and moderated provincially. It was evident that the learners consistently had trouble responding well to questions based on probability. The researcher has therefore experienced a need to explore how the concept of probability is developed in Grade 6 mathematics classes.

This study therefore sought to explore the teaching strategies used by mathematics teachers to teach Grade 6 learners the topic of probability. Grade 6 learners are expected to carry out probability experiments by performing simple repeated events; listing possible outcomes for experiments such as tossing a coin, rolling a die and spinning a spinner; and counting and comparing the frequency of actual outcomes for a series of up to 50 trials (DBE, 2011b, p. 25).

1.3. PROBLEM STATEMENT

The rationale behind exploring the teaching strategies used by mathematics teachers to teach Grade 6 learners probability was necessitated by both national and international reports; these are discussed below based on the data provided in Tables 1.1, 1.2 and 1.3, and Figures 1.1, 1.2, 1.3 and 1.4 in the rest of the chapter.

1.3.1. National reports on learner performance in mathematics

From the national reports, a comparison of the ANA results for 2011 and 2012 in Mpumalanga (Table 1.1 below) show a decline in learner performance in mathematics by 1.6% (from 25% to 23.4%), but from 2012 to 2013, the performance increased by 10.2% (from 23.4% to 33.6%) and from 2013 to 2014, the performance increased further.

Table 1.1: The average achievement by province in percentage (%) of Grade 6 learners in mathematics for the past four years (DBE, 2011b, p.20; 2012, p.35; 2013, p.49; 2014, p.57)

Province	**2011**	**2012**	**2013**	**2014**
Eastern Cape (EC)	29	24,9	33	36,8
Free State (FS)	28	28,4	40	47,7
Gauteng (GP)	37	30,9	44,7	51,1
Kwa-zulu Natal (KZN)	32	28,1	41,2	43,8
Limpopo (LP)	25	21,4	32,9	35,3
Mpumalanga (MP)	**25**	**23,4**	**33,6**	**39,9**
Northern Cape (NC)	28	23,8	35,6	39,3
North West (NW)	26	23,6	36,5	38,8
Western Cape (WC)	41	32,7	44,9	50,9
South Africa (SA)	30	26,7	39	43,1

Learner performance could also be interpreted by considering the yearly percentage increase or decrease, namely:

- ◊ Between 2011 and 2012, there was a percentage decrease of 6.4%;
- ◊ Between 2012 and 2013, there was a percentage increase of 43.6%; and
- ◊ Between 2013 and 2014, there was a percentage increase of 18.8%.

The 10.2% improvement in learner performance from 2012 to 2013 is due to the intervention strategies introduced in schools ranging from enhanced curriculum mediation, to strengthened numeracy strategy, and effective provision of appropriate learning and teaching support materials to districts and schools (DBE, 2013, p.8).

The pass rate for mathematics in Grade 6 in South Africa for 2014 was 43.1%. Since ANA is a critical measure for monitoring progress in learner achievement, the benchmark for average or expected percentage will always be 50% (See Table 1.2 below). Table 1.2 indicates a steady increase of 8% per year in target performance from 2011 to 2014 on average.

Table 1.2: National targets in percentage of learners achieving 50% and above for the period 2011 to 2014 (DBE, 2012, p.5)

2011	2012	2013	2014
35	44	52	60

According to Table 1.2, the overarching goal is that by 2014, at least 60% of the learners in Grade 6 should achieve the acceptable level, which is 50% and above. However, comparing the data presented in Tables 1.2 above and Table 1.3 below indicates that the provinces, and the overall national performance, failed to meet the projected target performance for 2012 to 2014.

This trend compels the view that the overarching target of 60% of learners achieving 50% or above in mathematics for 2014 is unrealistic. Table 1.3 indicates that the Mpumalanga province had 5.7% of learners in 2012, 16.1% learners in 2013, and 27.0% learners in 2014 achieving at 50% and above, which is far below the target percentage of 44%, 52% and 60% respectively. Thus, the dilemma of the poor performance of Grade 6 learners in mathematics constitutes a serious issue of concern, both at national level and in the Mpumalanga province in particular.

Table 1.3: Percentage of learners achieving 50% or more in Grade 6 mathematics per province (DBE, 2012, p.35; 2013, p.49; 2014, p.70)

PROVINCE	**2012**	**2013**	**2014**
EC	8,1	16,2	23,3
FS	11,7	26,5	44,0
GP	16,4	38,4	51,7
KZN	11,8	30,4	36,4
LP	4,6	15,3	21,3
MP	**5,7**	**16,1**	**27,0**
NC	7,6	20,5	28,2
NW	7,1	20,8	26,6
WC	19,9	37,7	50,9
SA	10,6	26,5	35,4

The table indicates that there is improvement in the mathematics performance from 2012 to 2014, but not necessarily in the field of probability. For 2013 and 2014, probability as a concept was not assessed in the ANA paper. This is because the ANAs are written in the third term and probability is only taught in fourth term.

1.3.2. International (SACMEQ) reports on learner performance in mathematics

From the international reports, the Southern and Eastern Africa Consortium for Monitoring Education Quality (SACMEQ) undertook three research projects, namely: SACMEQ I, SACMEQ II, and SACMEQ III. The projects focussed on the quality of education in primary schools.

According to Hungi, Makua, Ross, Saito, Dolata, van Cappelle, Paviot and Vellien (2011, p.1), the aims of SACMEQ have been outlined as follows:

- To gain the technical skills required to monitor and evaluate general conditions of schooling and quality of their own basic education.
- To undertake research that generates evidence-based information that could be used by decision makers to plan improvement in the quality of education.

In analysing the quality of mathematics education, SACMEQ describes the different competency levels as follows (See Figure 1.1):

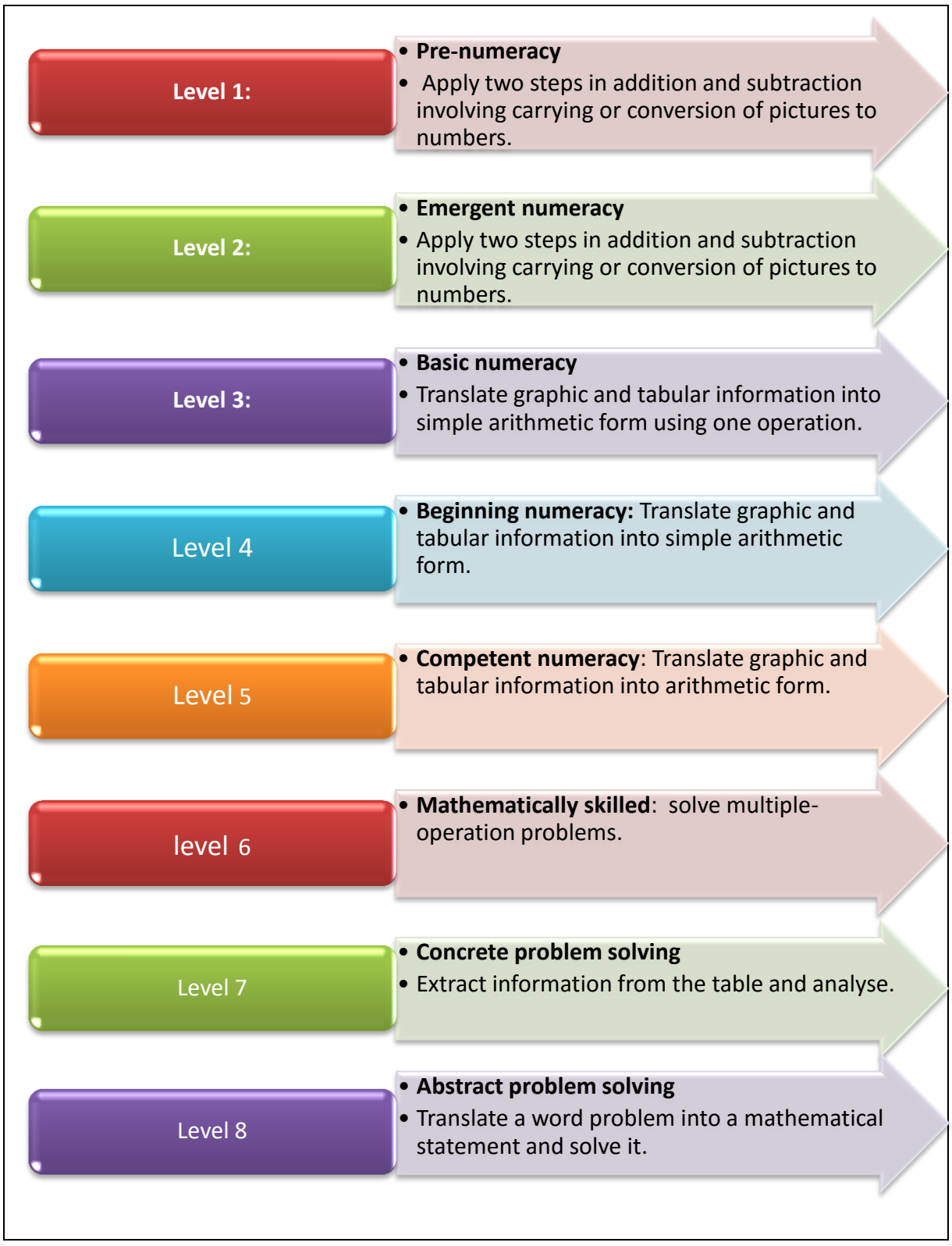

Figure 1.1: Different competency levels used by SACMEQ to analyse the quality of mathematics education (Moloi & Chetty, 2011, p.7)

The complexity of mathematical problems progressively increases from competency Level 1 to competency Level 8. In other words, problems at competency Level 1 are less complex, less difficult and less demanding than those of competency Level 2 in that order up to Level 8. In terms of the cognitive demand, competency Level 1 is the lowest and competency Level 8 is the highest. The test instruments for the assessment of the Grade 6 learners in mathematics were developed based on the above eight competency levels.

The SACMEQ III study sampled 61 396 Grade 6 learners from 4 countries comprising Botswana, Namibia, Mozambique and South Africa (Spaull, 2011, p.38). Out of the 61 396 sampled learners, 9 071 were South African. The SACMEQ III study in South Africa used the nine provinces as strata, namely, the Eastern Cape, the Free State, Kwa-Zulu Natal, the Northern Cape, North West, Limpopo, Mpumalanga, Gauteng, and the Western Cape. The factors considered when developing tests for assessing learners were textbooks and resources used in most schools. The implication of this statement is that questions that were used in the tests came directly from the textbooks used by Grade 6 learners. Figure 1.2 below provides a report on the mathematical competency levels of South African learners.

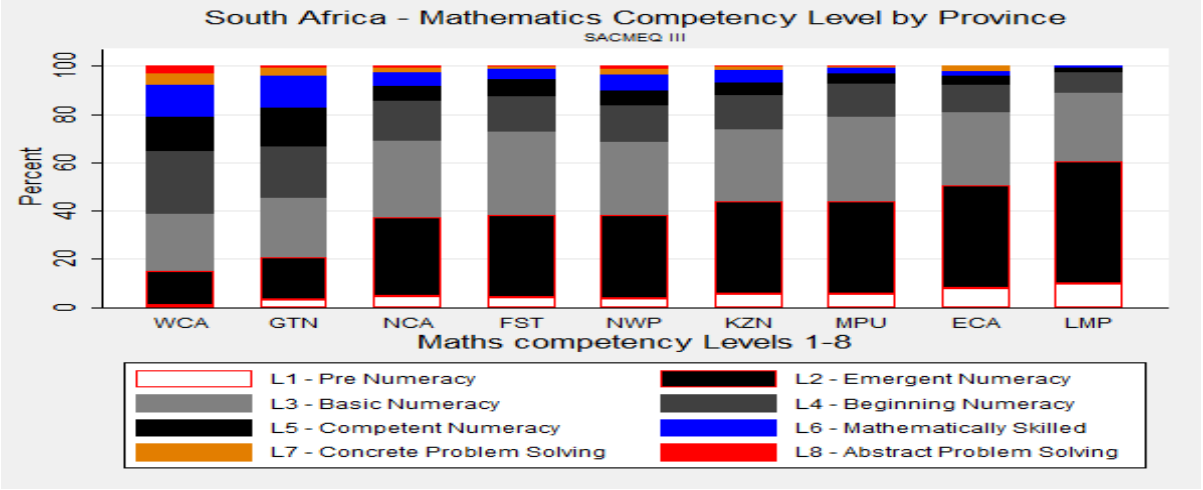

Figure 1.2**:** Mathematics competency levels of South African learners by province (Spaull, 2011, p.70)

The general trend in the performance of learners in all 9 provinces is that they did not perform well in Level 8, however, the graph showed that Mpumalanga registered zero percentage (0%) of learners operating at the 'Abstract problem solving' level (competency Level 8). Furthermore, the findings indicate an insignificant percentage of learners performing beyond competency Level 5 (beginning numeracy) up to competency Level 7. According to the SACMEQ III report, a large proportion of learners in Mpumalanga have neither mastered pre-numeracy (competency Level 1), nor the higher competency Levels 5 – 7.

Similarly, Figure 1.3 provides an analysis of the Grade 6 mathematics achievement of South African Grade 6 learners at each competency level for 2000 and 2007 (refer to Figure 1.2 for the descriptions of competency levels according to SACMEQ). This achievement is expressed in terms of percentages for each competency level, as described by SACMEQ. From the graph (Figure 1.3), it is evident that learners performed best in emergent numeracy (competency Level 2), and moderately in basic numeracy (competency Level 3), but performed the poorest in abstract problem solving in both 2000 and 2007 (Moloi & Chetty, 2011, p.7).

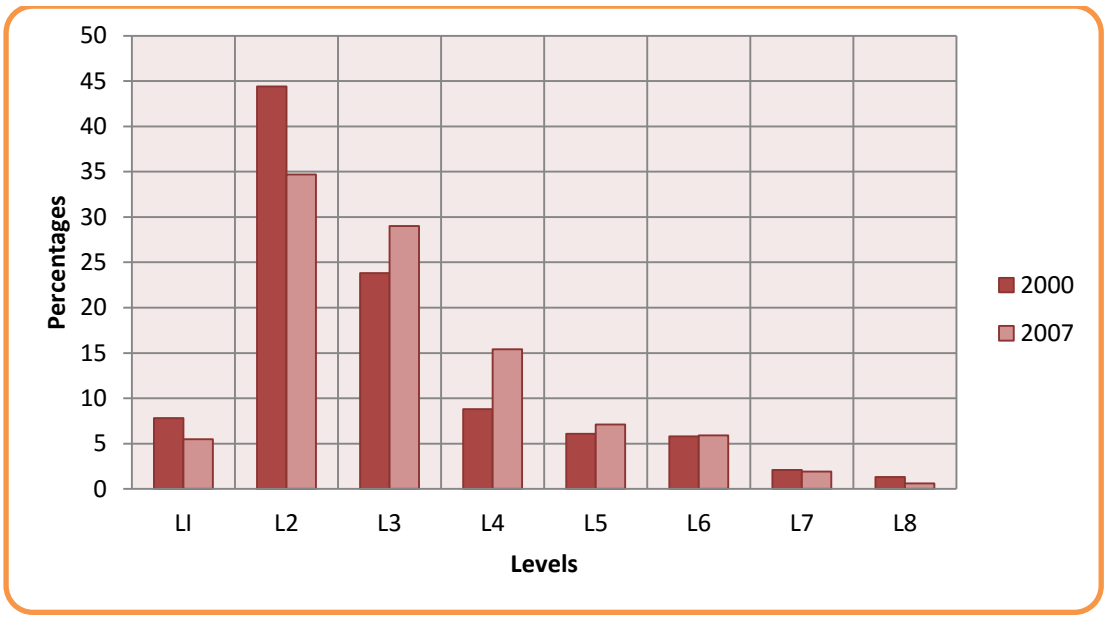

Figure 1.3: The mathematics achievement percentages of South African Grade 6 learners at each competency level (Moloi & Chetty, 2011, p.7)

The relative position of each country that participated in the SACMEQ study in 2011 is shown in Figure 1.4 below. Regarding the configuration of the graph, Spaull (2011, p.30) explains that, “the y-axis shows the average reading score, while the x-axis shows the average mathematics score”. Consequently, if an observation lies to the left of the diagonal line, this means that the observation has a higher reading score than the mathematics score, and when an observation lies to the right of the diagonal line, it means that the observation has a higher mathematics score than a reading score. The horizontal and vertical dotted lines indicate the SACMEQ averages for reading (510) and mathematics (512) respectively.

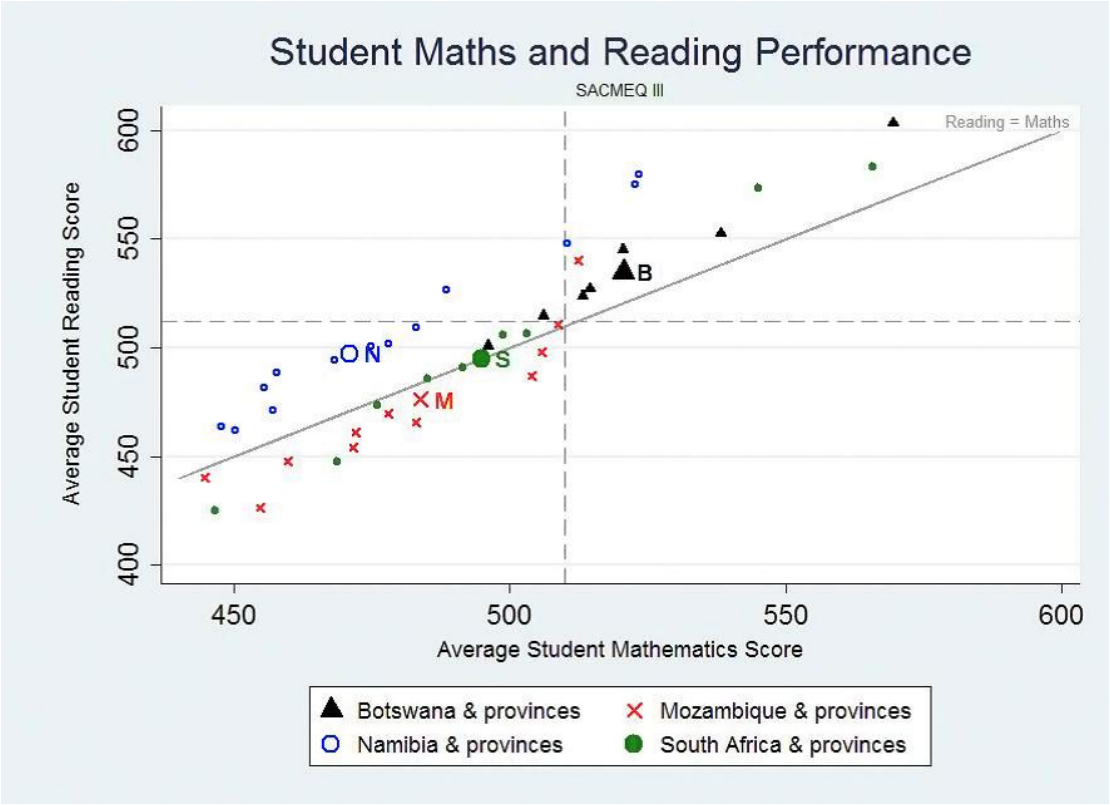

Figure 1.4: Grade 6 mathematics and reading performance (Spaull, 2011, p.30)

We can conclude the following based on Figure 1.4 (Spaull, 2011, p.30):

- The country averages for Namibia, South Africa, and Mozambique for both reading and mathematics are below the SACMEQ averages. Botswana, by contrast, performs marginally better than the SACMEQ average for both reading and mathematics.
- Botswana has the least variation in student performance of all four countries.

Again, this finding supports the findings of previous studies (See Figure 1.2) by indicating that Grade 6 learners perform poorly in mathematics in South Africa. The evidence provided in the secondary data (the figures and tables presented above), clearly shows that South Africa has not performed well when compared to other countries. Although the analysis is based on their performance in general, not particularly in probability, the researcher

developed an interest in conducting a study on how the concept of probability is developed in schools.

The reason for the researcher's interest in this area is that probability is a relatively new concept that has been included in the Curriculum Assessment and Policy Statement (CAPS), and it now appears as if the majority of teachers were never trained how to teach this topic, and it seems as if teachers are not confident and/or competent in teaching this topic. This observation, coupled with the earlier argument in Section 1.1 regarding the finding of the external moderation process, indicates that "Probability is one of the most misunderstood concepts by learners in Grade 6" (DBE, 2012, p.12). This illustrates the significance and practical value of this study.

The assumption made in this study is that intermediate phase teachers do not have adequate content knowledge (CK) as well as knowledge of appropriate strategies to successfully teach probability to Grade 6 learners. The researcher therefore found a need to observe such lessons in order to see how the concept of probability was unpacked in the lessons taught. In addition to this, the researcher developed a personal interest in exploring the strategies used by teachers in the teaching and learning of probability in order to contribute positively towards the development of mathematics teachers' classroom practice.

1.4. RESEARCH QUESTIONS

In view of the background against which this investigation takes place, the following research questions were developed to guide and direct this study.

1.4.1. Primary research question:

What are the teaching strategies used by mathematics teachers to teach probability to Grade 6 learners?

1.4.2. Secondary questions:

This primary question was addressed by answering the following secondary questions:

1. How do teachers enforce essential aspects to enhance learners' understanding of probability?
2. How do teachers implement appropriate approaches and guiding principles in teaching probability?

1.5. IMPORTANCE OF THE STUDY

The outcomes of this study will inform teachers regarding how various teaching strategies could be effectively used for teaching to result in meaningful learning. These strategies could contribute to learners in the Intermediate Phase developing a conceptual understanding of probability.

The findings of the study will elucidate the following:

- Restructuring the strategies used to teach and learn probability in Grade 6.
- Informing planning for in-service training or intervention workshops for teachers.

Most importantly, an exploration of the concept at this level is crucial because Grade 6 is the exit level for the Intermediate Phase. Content covered in this grade serves as the basis or the foundation for the Senior Phase (Grades 7-9) content. Teachers and Senior Education Specialists may consider discussing effective teaching strategies that they could use to improve their practice in teaching probability. These discussions could take place in circuit meetings or school-based meetings.

1.6. METHODOLOGICAL CONSIDERATIONS

1.6.1. Research approach

A qualitative research approach was used in this study. According to Creswell (2008, p. 46), qualitative research is "a type of educational research in which the researcher relies on the views of the participants, asks broad and general questions, collects data consisting largely of words, describes and analyses these words in themes and conduct the inquiry in a subjective manner". In this study, the major focus was on the in-depth inquiry of teachers' classroom practices in teaching probability.

1.6.2. Research design

The design used in this study was an interpretive case study design. The reason for the use of a case study is that it allowed the researcher to concentrate on a specific situation and to attempt to identify the range of interactive processes in a classroom setting (Babbie & Mouton, 2004, p.196).

1.6.3. Research site, population and sampling

The population for this study constituted teachers from primary schools in three different circuits in the Nkangala district. Three teachers from different schools were selected to provide insight into the teaching of the probability concept to Grade 6 learners. In view of this, the selected teachers and schools were provided information that contributed to a better understanding of the teaching of probability in Grade 6 mathematics classes. The background data relating to teaching experience, qualifications and learner performance in these schools were considered in selecting the participating teachers (see Chapter 4).

1.6.4. Data collection instruments and process

Two instruments, interviews and observation protocols, were used to collect data in this study. Data was collected through conducting individual semi-structured interviews and carrying out lesson observations. Each teacher presented two lessons on probability. The researcher spent two successive

days (day 1 and day 2) in each school. The interviews were conducted on the second day after the second lesson presentation and were conducted during break for 45 minutes. The semi-structured interview questions were used to gain a clearer understanding of these teachers' subject knowledge, understanding and opinions. The lesson observations were done during school hours and during the mathematics period of the Grade 6 class. The data collection process took almost two weeks to complete.

1.6.5. Data analysis and interpretation

Themes for analysing the data were derived from the literature that deals with this topic (Probability) with the aim of testing and expanding theory. The themes are: teachers' knowledge and understanding of probability (theme 1); and the effective use of appropriate teaching approaches (theme 2). Data was then gathered through the lesson observations and interviews with each teacher. After data collection, the data was manually analysed by describing information using existing categories. The findings were exemplified with explanations and specimens of typical teacher responses together with suggestions and recommendations.

1.6.6. Ethical considerations

The researcher obtained permission to conduct research from the University of Pretoria, circuit managers, and the principals and teachers of the selected schools. Details with regard to the role of the researcher, data collection and analysis processes were indicated in the permission letters. It was easy to gain access to the schools because all of the people the researcher requested permission from were eager to see this study implemented.

The researcher assigned pseudonyms to the participating teachers and their schools. The participants in this study were referred to as Teacher A, Teacher B and Teacher C. The schools were also identified as School A, School B and School C. The aim of this was to protect the anonymity of the participants.

Data was collected during normal school mathematics periods to avoid any disruption to the proper running of the school. The interviews were conducted during school breaks with the permission of the participants. The researcher had no prior association with the primary schools and was the curriculum implementer for the Senior Phase.

1.7. SUMMARY

This chapter presented an overview of the background to this study, the rationale for the study, the problem statement, research questions, importance of the study, methodological considerations, and the outline and organisation of each chapter.

In view of the problems identified in this chapter, it was therefore necessary that an inquiry be made to establish the causes and motivation behind the level of difficulty in teaching and learning probability in the Intermediate Phase, in particular, in Grade 6. The findings will hopefully inform teacher planning regarding effective strategies that can be used in the teaching and learning of probability. Below is a brief summary of the outline of each chapter.

1.8. OUTLINE AND ORGANISATION OF THE THESIS

Chapter 1: Introduction and overview

This chapter provided an overview of the study's background, the rationale for the study, the problem statement, research questions, methodological considerations, and the layout of the rest of the thesis.

Chapter 2: Literature Review

This chapter provides a review of related literature which focuses on the topic of this research. The review includes key concepts, principles of effective teaching in the South African Mathematical Policy and Educational context, the scope of probability in the Intermediate Phase, the definition of probability, the importance of probability, the terms and related language of probability,

the quality of teacher practice in the teaching of probability, gaps identified in the literature, and lastly, the theoretical framework that guided the study.

In the Senior Phase, learners are expected to determine the probabilities for compound events (CAPS, p.36). It is therefore important for learners in the Intermediate Phase to understand the definition and the language probability for application in higher grades.

Chapter 3: Research design and methodology

In this chapter, a detailed description of the methodology is provided. The methodology includes the research approach, design and methods used. The method is discussed according to the selection of participants, instruments used for collecting data, the data collection process, and the methods used for analysing the data. The following aspects were also considered during the data collection process: reliability, validity and trustworthiness of the study, as well as ethical considerations.

Chapter 4: Data presentation

This chapter provides a brief description of the analysis and interpretation of the collected data. The findings are presented under the categories and themes that emerged from the literature and the analytical process.

Chapter 5: Summary and conclusion

A brief discussion on the key findings and conclusions made in this study are provided. The chapter is concluded by looking at the strategies that were successful and how they compared with the literature. An answer to each research question is then presented, as well as the benefits to the field of study, shortcomings or limitations of the study, and recommendations for further research.

CHAPTER 2: : LITERATURE REVIEW

2.1. INTRODUCTION

Creswell (2008, p. 89) defines a literature review as "a written summary of documents such as articles and books that describe the past and current state of information." The researcher conducted this literature review so as to share the latest findings regarding this topic. This literature review was also used to structure and analyse the results of this study. The literature informed the researcher on the challenges with regard to:

- Developing conceptual understanding of mathematical concepts, including probability; and
- The extent to which this concept is nationally and internationally experienced as being complex.

The purpose of this chapter is to present the contributions of a large body of literature with regard to the teaching and learning of probability. It positioned this study in relation to the literature reviewed, and provided the conceptual framework that guided the study.

From the researcher's experience as a curriculum implementer (CI), it has been discovered that the Department of Basic Education (DBE), in general, places more focus on the Further Education and Training (FET) band than on the General Education and Training (GET) band in terms of offering the necessary support to teachers. It could be posited that, if the foundation is not properly laid in the GET band, the FET band could be negatively affected. This also affects the successful teaching and learning of mathematics in South Africa.

The following topics will be presented hereafter: Educational policies in the South African context; the concept of probability; strategies for effective teaching; teaching strategies in the context of probability; the gaps identified in the literature; the relationship between the conceptual framework and research questions; and the conceptual framework used in this study.

2.2. EDUCATIONAL POLICIES IN THE CONTEXT OF MATHEMATICS IN SOUTH AFRICA

The Republic of South Africa drew up and adopted a constitution (Act 108 of 1996) that provided the basis for curriculum change. The first kind of curriculum that was introduced after the new democratic government was elected was Curriculum 2005 (C2005). The approach used to deliver this curriculum was the Outcomes-Based Education (OBE) approach. This meant that the Learning Outcomes (LO) designed for the curriculum were informed by the critical-cross field outcomes. These critical cross-field outcomes were reflected in different subjects as Specific Outcomes. The achievement of the Specific Outcomes would assist in the realisation of critical outcomes.

Due to the difficulty in terminology and obscurity of the concepts to be taught in the classroom, the Revised National Curriculum Statement (RNCS, 2002) was produced for the Early Childhood Development (ECD), General Education and Training (GET), Further Education and Training (FET) and Adult and Basic Education and Training (ABET) bands. In the RNCS (Grades R-9), the mathematics content was extracted from Learning Outcomes (LO) and Assessment Standards (AS). There was, however, still a complaint from teachers that some of the assessment standards were ambiguous, hence another revision was required. The RNCS (Grades R-9) was then replaced by the National Curriculum Statement (NCS, 2011): Grades R-12.

The NCS Grades R-12 comprises three documents, which are: the Curriculum and Assessment Policy Statement (CAPS, 2011) for each subject; national policy pertaining to the programme and promotion requirements (NPPPPR); and the National Protocol for Assessment (NPA) Grades R-12. The CAPS document clearly stipulates the topics to be taught in each grade, as well as some clarification notes (content clarification) on how each topic should be taught. It also identifies the content that should be covered (content specification) in each grade, including the topic of probability in Grade 6.

It was therefore important to know and understand what probability is; the scope of probability for Grade 6; and the importance of and language used in

probability for the purpose of making conclusions with proper recommendations in terms of the teaching strategies used by teachers for mathematics instruction in the classroom.

2.3. PROBABILITY

In this section, probability as a mathematical concept is defined; the scope of Grade 6 probability within the South African context is stated; the importance of knowledge of probability as reflected in everyday life situations is discussed; and the language used in the topic of probability is also then presented.

2.3.1. Defining probability as a mathematical concept

Grinstein and Lipsey (2001, p.567) describe probability as "a field of mathematics that attempts to describe randomness." This implies that an event has an uncertain outcome. This section deals more with the possibility/likelihood of an event happening. The scale used in mathematics to describe the possibility of an event happening is from 0 to 1, in which "0" means that it is certain that the event will not happen, whereas "1" means that the event will certainly happen. Other events may occupy positions relative to 0 and 1.

Probability is defined as "the field of mathematics that measures the likelihood of an event to happen or not to happen" (Johnson & Mowry, 1998, pp.112-113). They explain that this theory was created to assist gamblers, and could thus be applied to games of chance. Bhat (1999, p.1) also defines probability as "a measure of the chance of occurrence of events." These definitions imply that any event has an uncertain outcome.

It is evident from the definitions given above that probability is a mathematical term that should be thoroughly explored through the use of specialised language and practical activities. The researcher is therefore convinced that probability should be understood as a yardstick for measuring uncertainties or certainties. In any teaching or learning situation, in order to stimulate learners'

interest in developing a particular concept, it is important to briefly indicate its importance, particularly in people's everyday life experiences.

The next section presents the content and skills that need to be covered in Grade 6 with regard to the teaching and learning of probability.

2.3.2. Scope of probability In Grade 6

According to CAPS (DBE, 2011, p.25), Grade 6 learners are expected to carry out probability experiments by:

- Performing simple events repeatedly;
- Listing possible outcomes for experiments such as tossing a coin, rolling a die and spinning a spinner; and
- Counting and comparing the frequency of actual outcomes for a series of up to 50 trials.

The policy statement has also given some guidelines on how to teach the concept of probability. It emphasised that doing experiments with a coin is easier than with a die because the coin has two possible outcomes (head or tail), while rolling the die has six outcomes (numbers 1 to 6). The spinner can have any number of outcomes, depending on the number of divisions made on the spinner.

Learners are expected to list the possible outcomes first before performing the experiments, record the results of their experiments in a table using tally marks, then count how many times heads or tails, or each number, or colour on a spinner, occurs after 20 trials. If learners do this in groups, the results from all the groups can be collated. They can then compare the number of outcomes that occur as the number of trials increase.

The curriculum thus emphasises the use of the experimental approach in teaching probability. One of the advantages of the experimental approach is that results emanate from experiential practices. This is fun and it motivates learners to learn through play. "Introduction of real-world probabilities into the mathematics curriculum can challenge teachers who may prefer to focus on

classical probability where there is always one right situation and one right computation-based answer" (Gal, 2009, p.58). It is also important to gain an understanding of how probability could be used in a real-life situation.

2.3.3. The importance of probability

Kazima and Adler (2006b, p. 47) highlight that "in the teaching of probability, issues of everyday knowledge and language come to the fore." They indicate that its importance emanates from the fact that the world is full of uncertainties. To put it in another way, probability as a mathematical concept assists us in terms of interpreting uncertainties in the world. Kazima and Adler (2006b) concur with Bell, Bell and Carrol (1999, p.18) that we all know the world is full of uncertainties, for example, probability is used to interpret graphical representations and is used in most cases by insurance companies to cover inflation for pure investments and risk for death and accidents.

Johnson and Mowry (2011, p.113) explain that:

- Probability is used to analyse death records,
- English firms use mortality tables to make their fees appropriate to the risk involved; and
- Probabilities can be used to determine the most probable true size of a quantity when repeated measurement of that quantity varies somehow.

From the examples given above, it shows that probability, if taught proficiently in the classroom, could be used to interpret experiences in real-life situations. For teachers to teach the concept of probability in an understandable way, the curriculum emphasises the use of appropriate terminology and language.

2.3.4. The language used in probability

Language is a vehicle for communication, and mathematics is a specialised language used to communicate and model real-life situations. To be literate in any sphere of life, it is important to be competent in the unique language used in that particular sphere. It is therefore important to understand the language

of probability in order to acquire knowledge or develop skills to interpret real-life experiences.

Bell et al. (1999, pp.19-20) note the fact that "for learners to understand a particular concept, it is important to start by developing their vocabulary." They cite examples of terminology used in probability to include 'sure', 'certain', 'probably', '50-50' chance, 'not likely' and 'impossible', among others. They advise that these terms need not be taught formally, and that learners will gradually make them part of their vocabulary through repeated use.

Learners at the primary school level are therefore expected to use the terms 'predict' or 'possibility', because 'probability' sounds very complex to learners in the Intermediate Phase. For instance, people talk about the possibility of contracting diseases, winning a game, becoming the next president of the country, the possibility of being promoted to the next level, and the possibility of winning the lotto. To understand and make meaning of this information, learners should have enough time throughout their school years to learn about probability concepts and how to use them in their everyday lives. The terms that are frequently used in developing the language of probability will now be discussed.

2.3.4.1. Randomness

Bell *et al.* (1999, p.19) describe a random event as "the event selected from a set of events, all of which have an equal probability of being selected". For example, if you choose a number at random, it means you pick any number and as such there is no particular order that will be prescribed to choosing a number. They identify two challenges that might affect randomness, viz: 1) equal probabilities in the sense that these may be affected by the position of the spinner, weight distribution in a die, thoroughness of the shuffle of a card deck/coin; and 2) individual perception of what the results should look like - e.g. if you throw a die 12 times and get 12 fours, then the die seems to be suspiciously biased and the numbers did not have an equal chance, and therefore were not random. Jones, Langrall and Mooney (2007, p.912) argue

that elementary learners are expected to have an understanding of chance and random events through conducting experiments by using resources like dice, coins and spinners.

2.3.4.2. Fairness

According to Kazima (2006a, p.32), "learners judge the fairness of a game within the results of the game, within the process of playing the game and the nature of the game". It was also explained that the fairness of a game could be judged by, amongst other things, taking turns in the play, having an equal chance of winning or losing the game, that is, if the outcome of the trial is not known in advance, and if the procedure for playing is correctly followed. Kazima (2006a, p.30) also describes a 'fair game' in the context of mathematics as "a game that allows equal chances of winning for all participants."

There is an emphasis on the correct understanding of the contextual meaning of concepts being grasped in the teaching of probability. Fair may mean different things depending on the type of game, and on learners' experiences of what fair means. It can also be interpreted with respect to players, scores, rules, conduct of the play, and the nature of the game. It is therefore important for learners to realise that the outcomes of the experiment will only be reliable if the game or the experiment was fairly conducted. In understanding the context under which the experiment is conducted, learners will also be able to predict results.

Bell *et al.* (1999, p. 20) find that in conducting experiments "all outcomes must be equally likely to happen such as tossing a fair coin, spinning a spinner that is divided into equal parts. For example, if the spinner is not divided into equal parts, the bigger space will have more chance of happening." The advice given in this instance was that experiments should be repeated several times for learners to gain a better understanding of dealing with the context of probability, and being able to make predictions.

2.3.4.3. Making predictions

Learners are expected to make some predictions before they can perform experiments. This is only possible if the learners understand the context under which they are operating. To give an example, for learners to have the ability to predict what will happen, the game should obviously be fair.

Grinstein and Lipsey (2001) advise that children should be encouraged to predict the possible outcomes, analyse and interpret the outcomes, and compare the actual outcomes and predicted outcomes. Furthermore, reviewing and reconstructing ideas through effective communication will challenge any misconceptions that learners have.

2.3.4.4. Explanation of basic terms used in analysing probability results

In addition to the language used in probability, Johnson and Mowry (2011, p.120) identify the basic terms used to analyse the results of an experiment as follows:

- Experiment: A process by which an observation or outcome is obtained;
- Outcome: The result of an experiment;
- Sample space: The set of all possible outcomes of an experiment;
- Event: Any subset of the sample space; and
- Frequency of outcomes: A number of times a particular outcome appears when an experiment is conducted.

There are many concepts that are used in probability, however, the researcher has confined herself to the ones mentioned above because they are within the scope of Grade 6 probability and mathematics coverage. Furthermore, the proper understanding of probability concepts mainly depends on both the mastery of language and effective teaching of the concepts. It is therefore important to gain an understanding of the quality of teacher practice in the teaching of probability.

The next section describes strategies for effective teaching.

2.4. STRATEGIES FOR EFFECTIVE TEACHING

In this section, a strategy as a concept that is used in the context of teaching and learning; the principles of effective teaching; a teacher's organisation of the lesson; a teacher's instructional assessment; and improvement of the quality of teacher practice in teaching mathematics is defined below.

2.4.1. Definition of teaching strategies

From the researcher's experience as a CI, a strategy in the context of teaching and learning was understood to be an approach that teachers could use to assist learners to achieve the objectives of a lesson. It can also be described as the use of certain techniques to make learning easier in a way that accommodates all the learners in the classroom.

According to Antony and Walshaw (2009), teaching strategies encompass all actions in and out of the classroom such as organisation and planning of lessons, arrangement of learners, delivery of lessons based on learners' experiences, effective communication using appropriate language and tools/materials, as well as lesson assessment based on the outcomes of the lesson.

In their introductory remarks, Kazima, Pillay and Adler (2008, p.283) highlight the fact that "teachers must be able to select and clarify appropriate mathematical goals for any lesson taught, sequence mathematical tasks and be able to evaluate the mathematical worth of a learner's explanation or argument". The implication of this statement is that teaching needs thorough preparation in terms of how the concept should be developed and how the lesson should be assessed. The context of the classroom will therefore dictate what kind of approaches teachers should use to make a lesson a success.

In support of this argument, Al-Haddad (2010, p.27) indicates that "some of the challenges that make teaching and learning unsuccessful, emanate from how the concepts are developed and assessment tasks are developed". This implies further challenges, namely the way the questions for the tasks are

structured, as well as identifying the possible misconceptions about probability that the learners may have. Above all else, the teacher must be able to interpret and accurately convey the curriculum materials to learners. This implies that teachers should be able to clarify concepts and guide learners to make meaning of their learning.

The focus of this study was on the strategies used by teachers to effectively teach Grade 6 mathematics learners the concept of probability. These strategies include teaching and learning approaches; principles of effective teaching; a teacher's organisation of the lesson; a teacher's instructional assessment; improvement of the quality of teacher practice in teaching mathematics, and all actions that a teacher may use to actively engage learners in constructive learning.

2.4.2. Teaching and learning approaches

For the purpose of this study, cooperative learning as a teaching and learning approach was linked to the principle of effective teaching (arranging learners into groups); discussion as a teaching and learning approach was linked to the use of correct mathematical language; and problem-based learning was viewed as a teaching and learning approach that is linked to both worthwhile mathematical tasks, and assessment. In addition to this, discussion is a teaching and learning approach that is integral to cooperative learning and problem-based learning because, in order for learners to interact with each other, they need to carry out a discussion. Learners also need to discuss the strategies of solving a problem or task given to them. Discussion is also integral to other approaches; this implies that it will always form part of other teaching approaches.

2.4.2.1. Cooperative learning

In this approach, learners are provided opportunities to discuss, share and work as a team to reach a particular goal. To emphasise the importance of cooperative learning, Akinsola and Ifamuyiwa (2008, p.83) explain that cooperative learning can serve the purpose of tutoring, remediation, enrichment and can assist with brainstorming. In addition to that, Balasorooriya, Corpo and Hawkins (2010), advise that to foster a productive learning environment, teachers have to allocate roles to learners, allow learners to lead an activity, pair learners with complementary strengths, allocate time for reflection at the end of the lesson, model the behaviour that is expected of learners, speak to learners individually, and increase motivation in small groups. Similarly, Jebson (2012) points out that meaningful learning cannot be guaranteed in a classroom that contains a large number of learners. In his study, he advised teachers to form learning groups.

In support of this assertion, Stols, Kriek and Ogbonnaya (2008, p. 109) emphasise that:

> As students work in groups to solve problems and present their work to their groups, they will have opportunity to learn from each other. Collaborative group problem-solving activities improve students' higher order thinking skills. Problem solving in the group allows the students to become more deeply involved in their learning process.

In line with this, Akinsola and Ifamuyiwa (2008) assert that the theory of cooperative learning is based on the fact that individuals depend on each other's effort to achieve the goal. That is, members of the groups learn from each other. Working together will assist them to accomplish a common learning goal.

What is important about group work is that each member must have a role to play. A major challenge, however, according to Fuentes (2013, p.49), is that if "group members' roles are not clear, they might end up not working at all, working individually or one member dominating the situation". Fuentes (2013)

therefore encourages teachers to ensure that there is quality of discussion in small groups, and redefine classroom norms and roles to enhance learners' mathematical understanding.

2.4.2.2. Discussion

Stols *et al.* (2008, p.109) state that in discussion as a teaching approach, the teacher presents the lesson by actively involving the learners during the discussion. They highlight the fact that for learners to engage in a meaningful learning experience; teacher-guided activities should encourage learners to:

- discuss alternative strategies with their teacher,
- observe many and alternative ways of examining a situation,
- learn through misconceptions; and
- Interact meaningfully to deepen their learning and construct knowledge.

2.4.2.3. Problem-based learning

Hassan (2010, p.85) refers to problem-based learning as "learning that results from the understanding and resolution of a problem." Trowbridge, Bybee and Powel, (2000, p.33), and Killen (1998, p.106) (as cited in Loggerenberg-Hattingh, 2003, p.52) define problem-based learning as "a process of using existing knowledge in an unfamiliar situation to gain new knowledge". De Graaf and Kolmos (2003, p.658), meanwhile, refer to problem based learning as a model that allows "the learning content to be related to the context, which promotes students' motivation and comprehension".

Hassan (2010) highlights the fact that the problem-based learning protocol should provide stimuli for learning in the form of questions posed by the facilitator, and not only be in the form of a problem. This implies that probing questions should be asked to lead to the construction of knowledge. In support of Hassan (2010), Malan, Ndlovu and Engelbrecht (2014, p.2) emphasise that "problem-based learning stimulates learners to become more involved and to take responsibility for their learning."

Furthermore, Hattingh and Killen (2003, p.45) support this argument in indicating that “facilitating learning in a problem-based environment and using cooperative learning demand that teachers should ensure that meaningful learning takes place”.

2.4.2.4. Experimental learning

According to CAPS (DBE, 2011), Grade 6 learners are expected to perform probability experiments by performing simple events repeatedly. In this case, learners were expected to perform experiments, after which they had to list the outcomes of the results, and recorded these on tally tables. Gal (2009, p. 58), who supports the experimental approach, explains that “the introduction of real-world probabilities into the mathematics curriculum can challenge teachers who may prefer to focus on classical probability where there is always one right situation and where there is always one right situation and one right computation-based answer”.

2.4.3. The principles of effective teaching

Teachers’ pedagogical knowledge (PK) involves various principles that should be employed for the effective teaching of probability. These principles and guidelines on how to teach probability effectively are categorised and discussed below in Table 2.1.

Table 2.1: Principles of effective teaching (Antony & Walshaw, 2009)

Principles of effective teaching	How to enhance the principle
Arranging learners into groups	Opportunities should be created for learners to work as individuals or in small groups.
Building on learners' thinking	Activities developed should be built on learners' experiences and interests.
Worthwhile mathematical tasks	Learners should be able to make sense of mathematics and become broad minded. They must be able to justify their solutions.
Making connections	Learners should be able to apply what they have learnt to their own real-life situation.
Assessment for learning	Informal assessment should aim at diagnosing learning issues and inform teaching and learning decisions. Summative assessment should aim at assessing the product in the teaching and learning situation.
Mathematical communication	Learners should be engaged more in using various ways of finding the answers than finding the correct answers.
Mathematical language	The use of correct language is encouraged, which includes the use of correct mathematical terminology. The teacher is expected to explain the terminology to the learners for better understanding of the concepts.
Tools and representations	Teachers should use appropriate resources, mathematical models and technology to support learning.
Teacher knowledge	Substantial content knowledge and pedagogical knowledge of teachers should assist learners to develop grounded understanding. Teachers should be able to respond to learners' mathematical needs using their knowledge.

Indeed, the extent to which a teacher applies these principles defines his or her teaching strategies in the classroom. The teacher' pedagogical content knowledge (PCK) also influences their teaching strategies, which in turn reflects in the teacher's actions in the classroom (Antony & Walshaw, 2009). In view of this, Speer, Smith and Horvath (2010, p.100) argue that "the principles and strategies that the teachers employ in teaching, shape the teachers' classroom practices and actions".

2.4.4. A teacher's organisation of the lesson

Organisation of the lesson refers to the "structure and order of the lesson activities, specific elements included in the lesson, such as pre-knowledge, concepts and skills to develop, resources, duration and the order in which each element of the lesson occurs" (Antony & Walshaw, 2009). They further add that it includes a review of work done in the previous lesson, marking/discussing homework, introduction of a new topic, development of the topic, paper and pencil exercises, group activities, learners' work, and consolidation of the educator's presentation.

2.4.5. A teacher's instructional assessment

Assessment is part of the instructional process that should be incorporated into classroom practice to adjust or inform teaching and learning. CAPS (2011, p.294) describes informal assessment as a daily monitoring of learners' progress with the aim of providing feedback to learners, as well as to inform planning for teaching. Antony and Walshaw (2009) explain that informal assessment aims at diagnosing learning issues and informs teaching and learning decisions, whilst summative assessment, alternatively, aims to assess the product in the teaching and learning situation. Formative assessment informs teachers about learners' level of understanding. Learners could be assessed through observation, which would assist teachers to gather evidence of the learners' learning.

2.4.6. Improvement of the quality of teacher practice in teaching mathematics

To improve the quality of mathematics teachers' practices in teaching probability, Kazima *et al.* (2006) argue that there is a need for the development of appropriate activities to be implemented in the classroom. Despite the fact that this recommendation was made for secondary school level, this study's view is that this is even much more crucial for primary school learners. This is because probability is initially introduced in the Intermediate Phase.

To emphasise the importance of good practice in the classroom, De Clerq (2008 p.9) also finds that "South African teachers need to approach their work as professionals, not as workers or civil servants". This implies that teachers should take responsibility for improving how they relate or interact with learners.

As mentioned earlier, Al-Haddad (2010) argues that the challenges are inherent in tasks and concepts. This argument is supported by Kandermir and Gür (2009, p.1630), who propose that "more research is needed on developing appropriate tasks and the mathematical work teachers do and need to do as they teach probability in a range of classroom contexts". More emphasis should be placed on different types of questions, as well as the purpose of the questions that teachers pose in developing the concept of probability.

Batanero, Godino and Roa (2004) note that "teachers lack specific preparation in statistics education." From this study, which was carried out in Spain, they emphasise that secondary teachers do not receive training in statistics education, and primary teachers often do not have basic training in statistics. The next section will discuss teaching strategies in the context of probability.

2.5. TEACHING STRATEGIES IN THE CONTEXT OF PROBABILITY

This section presents teaching and learning in the context of probability; teachers' actions to effectively teach probability; learners' actions to effectively learn probability; and teachers' knowledge and understanding of probability.

2.5.1. Contextualising the teaching and learning of probability

Learners experience probability in their everyday life activities without understanding the actual mathematical concepts on which such activities are based. In support of this assertion, Kazima and Adler (2006b) highlight that learners' everyday experience of tossing a coin does not necessarily include an understanding of actual mathematical independence. The implication is that teachers should have deep conceptual understanding of probability to provide opportunities for learners to develop conceptual understanding. In view of this, Gal (2009) emphasises Kazima and Adler's (2006b) idea by indicating that teachers should not assume that activities that are not contextualised will enable learners to interpret, reflect upon and think critically about diverse probabilistic situations that may be encountered in real-life. Gal (2009) further indicates that learning probability is not about spinning a spinner and rolling a die (classical probability situations), but it is for learners to interpret situations and make some predictions in real-life contexts.

Based on these arguments, it should be taken into consideration that learners are to be given opportunities to describe their thinking and understanding through the use of correct probability language. From the discussion above, it is evident that the focus is on understanding probability concepts through experiential learning. It means that the relevant concepts should be better explained through experiential learning by first doing activities that will assist learners to understand the concept better. Another important aspect to consider is that the purpose of learning a particular aspect must be clarified for learners to contextualise their learning.

Furthermore, Kandermir and Gür (2009) concur with Kazima and Adler (2006b) that probability could be understood through the use of a problem–solving method. This approach is explained as a process in which open-ended challenging questions are used, which also requires divergent thinking. They have also indicated that it is important for teachers to understand cultural practices and related intuitions that learners have about dice, which are drawn from their everyday experiences. In this regard, it is emphasised that the strategy of problem-solving is needed for learners to understand concepts and the language used, as well as addressing the contradictions identified in learners' cultural knowledge and experience (Kazima & Adler, 2006b).

2.5.2. Teachers' actions to effectively teaching of probability

To shape teachers' strategies and actions to effectively teach probability, Table 2.2 provides the following guidelines:

Table 2.2: Teaching guidelines for teachers in teaching probability (Adapted from Mullens, 1995, p. 5; and Speer *et al.* 2010, p.101)

Encourage learners to:
• Be independent and initiative; • Communicate amongst themselves and come up with various ways of solving problems.
Use the following:
• Resources like dice, spinners, coins to simplify abstract theory in teaching probability; • Learners' responses to clarify identified misconceptions; and • Cognitive verbs like classify, analyse, predict and create when developing assessment tasks.
Ensure that:
• Enough time is provided for learners to think and construct knowledge; and • Learners are able to elaborate on their answers.
Do the following:
• Motivate learners and encourage participation throughout the lesson; • Use baseline assessment to check prior-knowledge; and • Engage learners in a situation that might challenge their previous conceptions in order to create contradictions, which will in turn encourage discussions.

The importance of the teaching guidelines mentioned in Table 2.2 above is to ensure that learning takes place through a series of steps that will enable learners to make sense of what probability entails.

2.5.3. Learners' actions to effectively learn probability

Grinstein and Lipsey (2001) extend the ideas of Adler *et al.* (2008) by indicating that, in trying to solve problems involving chance, learners should be encouraged to predict the possibilities that might arise; to carry out experiments to determine experimental probabilities; to analyse and interpret the results; and to compare their experimental probabilities with the original predictions. This implies that learners should be able to interpret situations and make some predictions in real-life situations.

Another aspect regarding knowledge and the understanding of probability is contained in Kvantinsky and Even's (2002) framework, which will now be discussed.

2.5.4. Teachers' knowledge and understanding of probability

Kvantinsky and Even's framework (2002, p.1) comprises seven essential aspects for teacher knowledge and understanding of probability, namely, the essence of probability; the strength of probability; different representations and models; alternative ways of approaching probability; basic repertoire; different forms of knowledge and understanding; and knowledge about mathematics. The framework describes and discusses the nature of each aspect.

2.5.4.1. The essence of probability

The essence of probability refers to what makes the concept of probability different from other fields of mathematics. This means that the approach or the strategy of teaching a concept is based on what the concept entails and how it should be taught differently in comparison to other mathematical

concepts. It is therefore important for teachers to understand the concept of probability. The essence of probability will be explained in terms of approaches used in developing the concept and in terms of what probability is.

Kvantinsky and Even (2002) describe probability as a way of dealing with problems related to uncertainty. They differentiate two kinds of approaches used in teaching probability as follows: the objective approach, which is assigned to an event that can be repeated, like tossing a coin, drawing cards from a pack or throwing a die. The subjective approach, alternatively, interprets probability as the degree of belief rather than the relative occurrence. Compared to the objective approach, the subjective approach represents a subjective judgement made by an individual, not an objectively measureable characteristic. In politics, for example, different people may allocate different probabilities to the same event if they have a different scope of view. To give a specific example: to predict who will be the next president of the country will depend on a person's knowledge of political issues; hence different names could be suggested.

In this study, the researcher determined the kind of approach that was used by the teachers in developing probability concepts, that is, whether the participating teachers used an objective or subjective approach.

According to Jones *et al.* (2007), Australia, the United Kingdom and the United States of America have incorporated elements of both experimental and theoretical approaches to probability measurement. The difference between the two approaches is that with experimentation (frequentist), the probability of an event is defined as the ratio of trials favourable to the event to the total number of trials, whereas with theory (classic), the focus is on the ratio of outcomes favoured to the total number of those focused on.

CAPS (DBE, 2011c) emphasises the use of an experimental approach in teaching probability. An experimental approach is advantageous in the sense

that results emanating from experiential practices avoid guessing, and it is fun to carry out. Gal (2009, p.58), who supports the experimental approach, indicates that "the introduction of real-world probabilities into the mathematics curriculum can challenge teachers who may prefer to focus on classical probability where there is always one right situation and one right computation-based answer."

2.5.4.2. Strength of probability

In developing the concept of probability, it is important to highlight its importance and how it can be applied in everyday life situations. Teachers should give examples on how probability is used in games, business, politics and insurance.

2.5.4.3. Different representations and models

Generally, activities on probability are represented by means of tables, tree diagrams, Venn diagrams, and formulas. However, in Grade 6, tree diagrams and tables are more relevant and applicable. The researcher also looked at other kinds of models that are used by teachers as a way of representing information. Tree diagrams are important because they are associated with series of events, whereas the area model is limited to events and does not entail more than two steps. Alternative representations that could be used at primary schools, especially at Grade 6 level, are tally tables to compare frequencies. In addition to this, learners can also make models of spinners, coins and dice and use them to perform some experiments.

2.5.4.4. Alternative ways of approaching probability

Kvantinsky (2002) describes the classic approach in probability as the ratio between the numbers of results that fulfil the desired event and the number of elements in the sample space. The experimental (frequency) approach in probability is described as the value at which the relative probability stabilises when the number of experiments is large enough.

2.5.4.5. Basic repertoire

The expectation is that teachers should have knowledge of the terms and topics connected to probability. Before learners can understand probability, teachers should make sure that they understand concepts like 'outcomes', fractions, ratio and percentage, 'never', 'more', 'almost impossible', and 'certainty'.

2.5.4.6. Different forms of knowledge and understanding

The researcher also looked at conceptual knowledge (mastery of probability concepts) and procedural knowledge (how probability concepts are developed) to evaluate how learners make meaning of what is taught in the classroom.

2.5.4.7. Knowledge of mathematics

Supporting knowledge means that, when dealing with abstract knowledge, models are to be used to support teaching and learning. This could be possible with inductive and deductive reasoning, because probability experimentation is used for establishing hypotheses. Withholding knowledge implies that when doing the experiment of an event several times, the relative frequency will approach probability. The limit of the experiment could be determined by calculating the probability.

2.6. GAPS IDENTIFIED IN THE LITERATURE

The level at which the concept of probability was introduced; the use of formal rules and formulae to develop the probability concept; and resources used in developing the concept of probability are presented and discussed below.

2.6.1. Level at which the concept of probability was introduced

Makina and Wessels (2009, p.56) clarify that "the introduction of probability in the secondary South African curriculum needs a serious reconsideration of the way it is taught to the learners." According to Grouws (1992, p.489), there is very little information available about how secondary school learners think

about chance, random events, and decisions under uncertainty. In addition to this, Kazima (2006) emphasises that probability was introduced for the first time in the Senior Phase before it could be introduced in the Intermediate Phase. According to CAPS (DBE, 2011), only two out of 210 hours are allocated to the teaching of probability in Grade 6. This is approximately 1% of the total teaching time in a year.

It may be that the little time percentage allocated to the probability section does not give teachers time to explore the concept up to the level where learners feel confident therein. The intention of the researcher in this case is to explore how the concept is taught in primary schools. The literature has clearly indicated effective strategies to use in enhancing teaching and also some guidelines on how to teach probability effectively. However, these guidelines are emphasised for teaching probability in secondary schools, and not necessarily in primary schools (See Tables 2.1 and 2.2). Not much has been done on how these strategies enhance learning in young learners and how teachers connect classroom probability concepts and real-life experiences in primary schools.

2.6.2. The use of formal rules and formulae to develop the concept of probability

In the Intermediate Phase, the expectation is that learners should be able to understand the relevant language and apply their understanding in an everyday life situation. Yet, there is more of an emphasis on using rules for computations. This is a challenge because on secondary level, the focus is more on the use of formal computation in solving mathematical problems rather than developing conceptual understanding of probability and its connection to everyday life. No formal rules are to be applied in the Intermediate Phase (CAPS, 2011c). In other words, there is more emphasis on applying rules than helping learners discover those rules. This is a challenge because applying rules does not equip learners for the smooth transition from primary to secondary school.

2.6.3. Resources used in developing the concept of probability

In most of the literature, including both textbooks and research articles, all the grades in basic education use almost the same resources such as a die, spinner, coin and cards. The use of problem-solving as a mathematical strategy is not used much as a way of allowing learners to invent their own strategies to solve problems and to think of appropriate resources that could support their learning.

2.7. THE CONCEPTUAL FRAMEWORK

According to Smyth (2004), an appropriate conceptual framework acts as a series of reference points from which one can identify research questions within the existing body of literature; it also aims to scaffold research.

The framework for this study is based on the seven aspects of teachers' knowledge and understanding of probability; principles of effective teaching; and teaching and learning approaches (cooperative learning, discussion and problem-based learning).

Figure 2.1 below presents a diagrammatic representation of the conceptual framework that underpins this study. It is drawn from the work of Mdaka (2011), Schneppers and McCoy (2013), Anthony and Walshaw (2009), Sullivan (2011), and Kvantinsky and Even (2002).

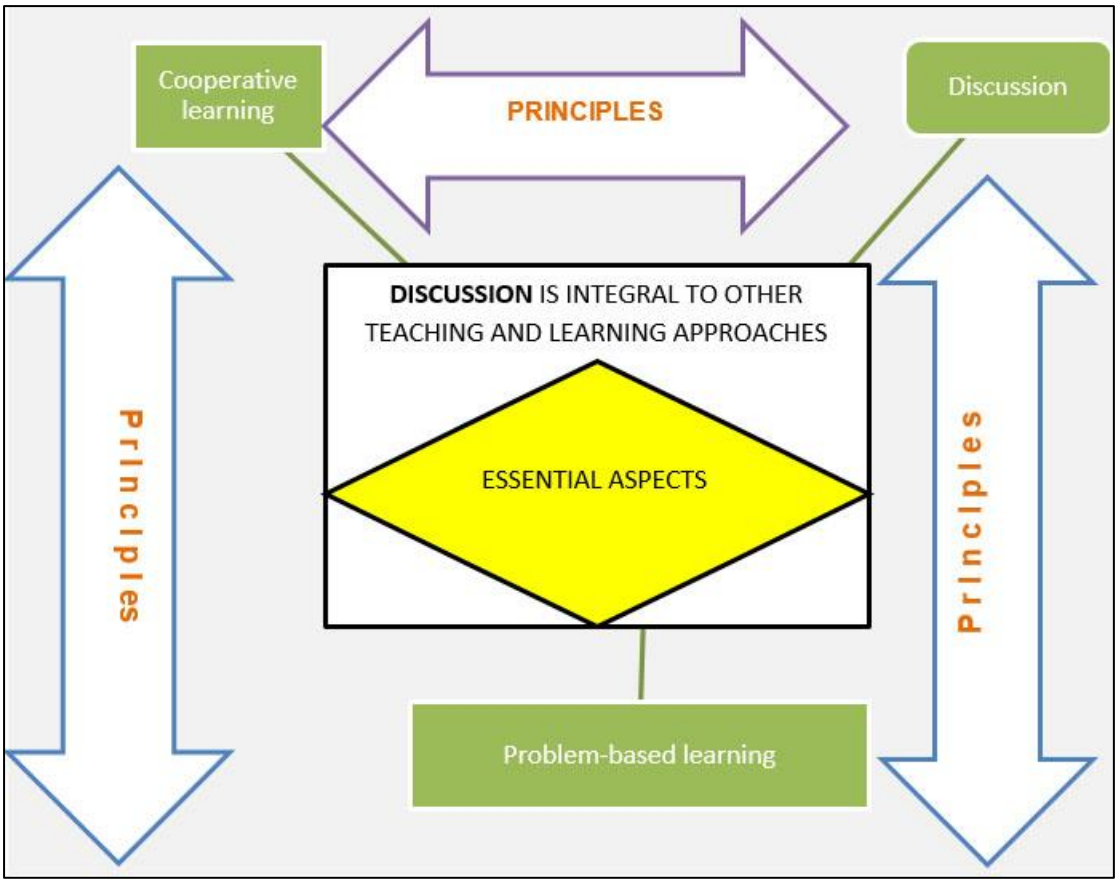

Figure 2.1: The schematic representation of the conceptual framework used in the study

The rhombus in the middle represents the essential aspects, which are key features that should be evident in the teaching and learning of probability. The teaching and learning approach of discussion is positioned in the middle because it indicates that this is integral to the other three approaches. Problem-based learning, cooperative learning, and experimental learning are the other approaches in the teaching and learning of probability. The arrows show the principles of effective teaching that are embedded in the approaches. The principles serve as a guide on how these approaches should be used. The double-sided arrows show that no approach can be used in isolation from another. The focus of one approach will definitely lead to the introduction of another approach.

The framework assisted in developing both the observation schedule and the interview protocol that were used in this study for data collection. Data was analysed using the elements in the framework. The discussions in Table 2.3 assisted in analysing the data.

Table 2.3: Essential aspects (with guiding questions) for teachers' knowledge and understanding of probability

ESSENTIAL ASPECTS
■ **Essence of probability** • Did teachers use both approaches to teach probability? • Did they use an *objective approach* that is assigned to an event that can be repeated, like tossing a coin, drawing cards from a pack or throwing a die? • Did they use the *subjective approach* whereby Probability is interpreted as the degree of belief rather than the relative occurrence? ■ **Strength of probability** • Did the activities developed highlight the importance of probability and indicate how concepts could be used in everyday life? ■ **Different representations and models** • Was information represented using different models like tree diagrams, Venn diagrams, tally tables and formulae? ■ **Alternative ways of approaching probability** • Did teachers use the classic approach whereby probability is defined as $\frac{number\ of\ desired\ outcomes}{total\ number\ of\ outcomes}$ or did they define probability as the value at which the relative probability stabilises when the number of experiments is large enough? ■ **Basic repertoire** • Was it evident that the teachers had knowledge of mathematical concepts connected to probability? Concepts including ratio, percentages, and fractions.
■ **Different forms of knowledge and understanding** • Did the teachers realise that procedural understanding is as important as conceptual understanding? ■ **Knowledge about Mathematics** • Did the teachers realise that understanding abstract knowledge requires the use of models? • Did they show understanding of the context of mathematics as a subject? To clarify this statement, according to CAPS: in mathematics for Grades 4-6 (DBE, 2011, p.8), for learners to develop essential mathematical skills they should: ■ Develop the correct use of the language of mathematics; ■ Develop number vocabulary, number concept and calculation and application skills; ■ Learn to listen, communicate, think, reason logically and apply the mathematical knowledge gained; ■ Learn to investigate, analyse, represent and interpret information; learn to pose and solve problems; build an awareness of the important role that mathematics plays in real life situations, including the personal development of the learner.

Table 2.4: Teaching approaches and guiding principles in the teaching and learning of probability (Ward 1987: 3–4)

Cooperative learning:	**Problem-based learning**
• Grouping style: how did the teachers group learners? • Were groups changed or maintained? • Were learners instructed to work as a group, sub-groups, pairs or as individuals? • What was the teacher's guidance to work on a given task? Were all the groups working on the same task or facets of tasks? **Discussion** • Did the teacher encourage learners to discuss amongst themselves? • Did learners engage in discussions to define a problem in a given activity? • Did they discuss how the problem should be solved? • How did the teachers facilitate the discussions?	• Were the problems given to learners practical and realistic? • Was the context familiar to learners? • Were they able to apply what they have learnt? • Were the questions posed closed or open-ended?

Table 2.5: The relationship between the conceptual framework and research questions in terms of data collection and analysis

Primary Research Question: What are the teaching strategies used by mathematics teachers to teach Grade 6 probability in the Nkangala District?			
Secondary questions	**Area of focus/Indicators**	**Data was collected through:**	**How has data been analysed** (Data was analysed by interpreting information from the observation protocol and interview schedule. The information was discussed in relation to the conceptual framework).
"How do teachers enforce the relevant essential aspects to enhance learners' understanding of probability?"	Guiding questions to enforce the essential aspects (see Table 2.3).	Lesson observations and Interviews.	**Data was analysed under the following theme:** Teachers' knowledge and understanding of probability. The researchers looked at how the essential aspects were enforced in a teaching and learning situation.
"How do teachers implement the appropriate approaches and guiding principles in teaching probability?"	The following teaching and learning approaches were used to guide the study: • Discussion; • Cooperative learning; • Problem-based learning.	Lesson observations.	**Data was analysed under the following theme:** Effective use of appropriate teaching approaches**.** This was done by looking at how teaching and learning approaches (cooperative learning, discussion and problem based learning, and experimental learning) and principles of effective teaching were used to make learning meaningful.

2.8. SUMMARY

This chapter provided an overview of educational policies in the context of mathematics in South Africa, probability as a mathematical concept, strategies for effective teaching, approaches in teaching and learning, teaching strategies in the context of probability, gaps identified in the literature, and the conceptual framework that guided the study.

The findings from the literature are that 'teaching strategy' is a broad term that could be regarded as an approach that teachers use to assist learners to achieve the objectives of a lesson. In some cases, approaches and strategies are used interchangeably. In this case, the effective strategy is determined as any strategy that results in meaningful learning. The choice of strategy depends on the context of the classroom. The teaching guidelines discussed in this chapter are also approaches that teachers could use in teaching probability. It also emerged in this chapter that probability has its own specialised language.

The conceptual framework used in this study was based on the essential aspects of teacher knowledge and their understanding of probability (viz., essence of probability, strength of probability, different representations and models, alternative ways of approaching probability, basic repertoire, different forms of knowledge and understanding, and knowledge of mathematics); the principles of effective teaching (arranging learners in groups, assessment of learning, mathematical language, and worthwhile mathematical tasks); and the approaches used in teaching and learning (cooperative learning, discussion, problem-based learning, and experimental learning).

The conceptual framework emphasised the fact that the mastery of concepts (probability language) alone is not sufficient to understand the concept of probability. It is therefore important to gain an understanding of the requirements for effective teacher practice to take place in teaching probability. The gaps that

were identified in the literature provoked an interest in pursuing a study on how probability is taught in primary schools.

The literature has confirmed that an understanding of the contextual meaning of concepts is very important. A consequence of the lack of guidance received by teachers on how probability should be taught in primary schools could have a negative impact on learners mastering the concept in secondary schools. This could be the case because in secondary schools formal rules and formulae are used to develop a concept.

In conclusion, a review of the related literature indicates growing support for the idea that more research is needed on the tasks and mathematical work that teachers do and need to do as they teach probability in a range of classroom contexts. The framework, as proposed by Kvantinsky (2002), includes the principles of effective teaching and approaches, which guided this research study. Because of the complexity of the term ‘strategy’, it is this study’s stance that conceptual frameworks should differ from one researcher to another. The next chapter provides a description of the research methodology of this study.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. INTRODUCTION

The purpose of this study was to explore and interpret the uniqueness of teachers' interpretation of the concept of probability and how it should be taught in primary schools. The research procedure that was used in conducting this study is described in this chapter with reference to the research paradigm and assumptions; the research approach and design; sampling procedures for the identification of the participating teachers; the data collection instruments; and the data gathering process. This chapter further describes the data analysis procedures; ethical considerations; as well as the quality assurance criteria.

3.2. RESEARCH PARADIGM AND ASSUMPTIONS

3.2.1. Research paradigm

A paradigm is "a set of assumptions or beliefs about fundamental aspects of reality which gives rise to a particular view" (Maree, 2007, p.47). He further explains that paradigms represent what one thinks about the world in which one finds oneself.

The basic assumptions and beliefs underlying this study are based on the Constructive Theory. Creswell (2008, p.50) clarifies that "the central perspective of constructivism stresses the importance of participants' view and the environment in which the view is expressed." He explains that the qualitative research paradigm focuses on the social construction of people's ideas and concepts (p.54). Due to the fact that this research explored the strategies used by individual teachers in teaching probability, its alignment with constructivism is further tested. This study is concerned with the uniqueness of how each teacher develops the concept of probability in their classroom.

3.2.2. Paradigmatic assumptions

The nature of this study is based on three assumptions, namely, the ontological, epistemological and methodological assumptions. In his work, Maree (2007, p.53-55) defines ontology as “the study of nature and form of reality”, epistemology as “the method of knowing the nature of reality” and methodology as “the technique used by the researcher to discover the reality”.

In this study, the idiographic position is taken as the ontological assumption that is concerned with the uniqueness of a particular situation (Maree, 2007, p.51). In this study, reality was viewed through words, and was regarded as how a situation is interpreted.

Regarding the epistemological assumption, this study holds an interpretive position that offers a perspective on analysing the situation and the way in which the participants made sense of their situations. This implies that the manner in which teaching and learning takes place in the classroom depends on how participants interpret the situation. Maree (2007, pp.59-60) finds that interpretivism originates from hermeneutics. He describes hermeneutics as the study of theory and the practice of interpretation. He furthermore indicates that the “interpretivist perspective is based on the assumptions that the human mind is the purposive source or origin of meaning and human behaviour is affected by knowledge of the social world does not exist independently of human knowledge.”

The nature of this study is subjective. The researcher was involved in constructing the meaning of each observed classroom situation.

3.3. RESEARCH APPROACH AND DESIGN

3.3.1. Research approach

Qualitative research was used as the research approach for this study. Creswell (2008, p.46) describes qualitative research as "a type of research in which the researcher relies on the views of the participants, asks broad and general questions, collects data consisting largely of words, analyses these words from themes and conduct the inquiry in a subjective manner." A qualitative research approach is "a naturalist and interpretive field of inquiry that draws on multiple methods of inquiry that is conducted in a naturalistic setting rather than controlled ones" (Rossman & Rallis, 2003, p.6).

Qualitative research is an "inquiry process of understanding a social or human problem based on building a complex holistic picture formed with words, reporting detailed views of information, rather than the explanation and prediction of human behaviour" (Babbie& Mouton, 2001, p.184). Alternatively, Denzin and Lincoln (2005) highlight the fact that qualitative researchers deploy a wide range of interconnected methods, always hoping to get rich and sufficient data on the subject matter at hand. In this study, an inquiry was conducted regarding Grade 6 mathematics teachers' practices of teaching probability. The purpose of the study was to investigate the strategies used by mathematics teachers to teach Grade 6 learners probability. To shed some light on teachers' practices, it was necessary to obtain their personal views and beliefs regarding the teaching of probability, but also to interpret how they use their knowledge of teaching this topic in their classrooms.

3.3.2. Research design

A research design is commonly described as all the processes involved in collecting, analysing and reporting on the data. MacMillan and Schumacher (2010, p.20) describe the research design as "the procedures for conducting the

study, including when, from whom, and under what conditions the data will be obtained." The design used in this study was an interpretive case study. Creswell (2008) defines a case study as an in-depth exploration of a bounded system. The reason for the choice of a case study was that it assisted the researcher in identifying the kind of strategies used by mathematics teachers to teach probability to Grade 6 learners. Furthermore, a case study permitted the researcher to investigate why a particular strategy was used during the presentation of a lesson by engaging the teachers in individual semi-structured interviews. During the interview, they motivated why they preferred to use the identified strategies.

3.3.3. Population and sampling

A population is defined by Creswell (2008, p.151) as "a group of individuals who have the same characteristics." The population in this study was the Grade 6 mathematics teachers in the Nkangala district, which comprised 20 circuits. The sample drawn from the population was three teachers from three different schools in different circuits. All three schools selected for this study were from a rural setting.

The purposeful sampling technique was employed in this study because the three teachers from the three different schools were selected to provide insight into the teaching of probability to Grade 6 learners. Teachers were selected on the basis that they had to be teaching mathematics to Grade 6 learners. The background data relating to teaching experience and qualifications was also considered in selecting the participating teachers. In this context, an experienced teacher was considered to be a teacher who had been teaching Grade 6 mathematics for more than five years. These teachers also had to have obtained an average of more than 60% learner performance for the past three years (2012-2014) in the end-year examinations. The background data relating to the teachers' experiences and qualifications is presented in Chapter 4.

The inquiry was carried out in schools during school hours. The participating teachers were working from the same Annual Teaching Plan (ATP) provided by the Mpumalanga Department of Education, but each teacher had his/her own lesson preparation, and they used different textbooks. The ATP outlines the topics to be covered, concepts and skills to be addressed, and the date on which each topic should be taught. It indicated that probability should be taught for two hours, and listed all the concepts and skills to be covered (see Section 2.3.2 in Chapter 2). The instruments and processes used in the data collection are discussed in the next section.

3.3.4. Data collection instruments

Data was collected through an observation of the teachers' lesson presentations and one-on-one semi-structured interviews with the teachers. The observation protocol and interview schedule were used as data collection instruments. The observation protocol herein is referred to as Appendix A and the interview schedule as Appendix B. The conceptual framework assisted in developing the data collection instruments and constructing a model for data analysis. All seven essential aspects, teaching and learning approaches and principles of effective teaching, as discussed in Chapter 2, also formed part of the observation protocol. These essential aspects and principles of effective teaching were described using the four-point scale to accommodate all the possibilities that might arise during the lesson presentation. The four point scale used in the observation protocol was adapted from the National Protocol on Assessment (DBE, 2005, p.9). The format and how each instrument was used are presented below.

3.3.4.1. Observation Protocol

Appendix A depicts the classroom observation protocol that was used to evaluate the lessons presented by the teachers. The same instrument was used for observing the two different lessons presented in each case. The observation protocol assessed the following:

- Knowledge of essential aspects for teaching and learning probability;
- Knowledge of how these aspects are enforced to enhance learners' understanding; and
- Teaching and learning approaches used to enable the teachers to present lessons that are comprehensible to learners.

The structure of the observation protocol is as follows:

Part A focused on the teaching and learning approaches, principles of effective teaching, arrangements of groups in class, the kind of questions asked and the purpose of each question at each stage of the presentation, how the teacher communicated with the learners and the use of mathematical terminology.

Part B focused on aspects of the teachers' subject knowledge and understanding of probability. This involved the development of practical activities, how the concepts were used in relation to real-life situations, the use of different representations in teaching the concept of probability, the use of formal rules in teaching probability, how the concept of probability was connected to other mathematical topics (show how other mathematical terms or topics are connected to probability), and whether activities done in class were based on procedural or conceptual knowledge.

3.3.4.2. Interview schedule

A semi-structured interview was chosen because "it allows the researcher to remain flexible, to permit participants to express their opinions, concerns and feelings so that important information can still arise" (Leedy & Ormrod, 2001,

p.67).The teachers were interviewed after the two lessons were presented. The aim of the interview was to triangulate the lesson presentation data. The structure of the interview schedule was as follows:

Part A: was based on the general questions aimed at finding out from the teachers about their experience in teaching the subject, ranking the various content areas in CAPS in order of preference to teaching it, how they benefited from workshops, and the importance of planning a lesson. Content areas in this context mean the main topics in mathematics.

Part B: Questions were related to teaching and learning. The focus was on the teaching strategies used by these teachers to teach probability, how the concept of probability was connected to a real-life situation, and what the teacher considered as very important in making a lesson a success, interesting and understandable for learners.

PART C: The focus was on reflecting about the lessons presented, whether the objectives were achieved, and how the teachers could improve their presentation for future lessons.

The questions that were used during the interview are presented in Appendix B.

3.3.5. Data collection process

The researcher requested permission from the circuit managers and principals of the selected schools to conduct this study. After permission was granted, the researcher met with the teachers of the selected schools with the aim of explaining the intentions and clarifying any concerns about the study. The three teachers were anxious to learn from the study because they indicated that probability is a new topic and they would learn a lot from their interaction with the researcher.

All three schools used a five-day cycle. In two of the schools, each period lasted for an hour and there was only one mathematics period per day. The duration of

each period in the third school was 30 minutes, and the teacher had two mathematics periods per day. In all cases, each lesson was presented for an hour. The data was collected over a period of two weeks.

The researcher spent two successive days (day 1 and day 2) in each school. In addition to that, interviews were conducted on the second day after the second lesson presentation and were conducted during break for 45 minutes. Each teacher was interviewed after having presented two successive lessons on probability. Semi-structured interview questions were used to gain a clearer understanding of teachers' subject knowledge, understanding and opinions.

The lesson observations were done during school hours and during the mathematics period of the Grade 6 class. The purpose of the lesson observations was to shed more light on the teaching strategies used by teachers in teaching probability to Grade 6 learners. To elaborate on this, two key issues were looked at. Firstly, how these teachers enforced the essential aspects of probability to enhance learners' understanding thereof was observed. The second issue was to see how these teachers implemented appropriate approaches and guiding principles in teaching probability.

In qualitative studies, observations are usually recorded in great detail, perhaps with field notes or videos that capture the wide variety of ways in which people act and interact (Leedy & Ormrod, 2001). Both the presented lessons and the interviews were audiotaped with the consent of the participating teachers. The field notes were also captured in both data collection instruments.

3.3.6. Data analysis and interpretation

Maree (2007, p.99) states that "qualitative data analysis is usually based on an interpretive philosophy that is aimed at examining meaningful and symbolic content of qualitative data." He indicates that, to understand how participants make meaning of a phenomenon, it is important to analyse their perceptions,

attitudes, knowledge, feelings and experience. He further indicates that codes and categories could be identified from other empirical studies dealing with the same topic.

For the purpose of this study, the themes from the literature that deal with the same topic were gathered with the aim of testing and expanding theory. The themes were identified as teachers' knowledge and understanding of probability (theme 1), and the effective use of appropriate teaching approaches (theme 2). Theme 1 comprised seven essential aspects, and theme 2 comprised three teaching and learning approaches. The essential aspects and teaching and learning approaches are herein referred to as categories. Data was then gathered through the lesson observations and interviews with each teacher. After the data collection, the data were manually analysed by describing information using the essential aspects in theme 1, and the teaching and learning approaches in theme 2.

The findings were exemplified with explanations and specimens of typical teacher and learner responses, but were also compared with the literature. Data from all the sources was captured using Microsoft Word, and were juxtaposed in tables to compare the findings. Categories under each theme are listed as follows:

Theme 1: Teachers' knowledge and understanding of probability

- The essence of probability (use of objective or subjective approaches);
- Strength of probability (application of knowledge in a real-life situation);
- Different representations and models (the use of models to represent information);
- Alternative ways of approaching probability (the use of formula or relative frequency to define probability);

- Basic repertoire (knowledge of concepts or sub-topics related to probability);
- Different forms of knowledge and understanding (the procedure used in developing the concepts and understanding of concepts); and
- Knowledge about mathematics (the nature of the topic and how it should be taught).

Theme 2: The effective use of appropriate teaching approaches

- Cooperative learning (criteria used for grouping learners, teachers guidance to work on given tasks);
- Discussion (facilitation of discussions amongst learners); and
- Problem-based learning (practical and realistic problems, contexts that are familiar or accessible to learners, application of knowledge gained).

The descriptions in brackets for each essential aspect and each teaching and learning approach were used to assess the teachers, and assisted in answering the main research question. The principles of effective teaching are embedded in these teaching approaches (see Table 2.3).

In presenting and analysing data, the following considerations were made:

- How the essential aspects were enforced to enhance teaching and learning probability;
- How appropriate approaches and guiding principles were implemented;
- comparison of teachers' teaching strategies, strengths and weaknesses; and
- Teaching strategies that were most effective in making learning a success.

The data was organised using the pre-determined categories under each theme. The researcher converted audiotape recording or field notes into text data and analysed the data from the transcriptions. For the purpose of triangulation, the

pre-determined categories from both the lesson observation protocol and the interview schedule were reconciled.

3.4. ETHICAL CONSIDERATIONS

Permission to conduct research was obtained from the University of Pretoria in the form of ethical clearance from the circuit managers, principals and teachers of the selected schools. The permission letters reflected the purpose of the research, the role of the researcher, how the data would be collected and analysed, and emphasised how the information would be kept confidential (see the permission letters attached). It was very easy to gain access to the schools because all the people, the researcher requested permission from, were eager to learn from the study.

To protect the anonymity of the participants, the researcher assigned pseudonyms to the teachers and their schools, for example, Teacher A, Teacher B and Teacher C. The schools were also identified as School A, School B and School C. During data collection, the researcher avoided disrupting the proper running of the school by observing lessons during the normal mathematics periods, and the interview was conducted during break. There were no potential power imbalances or inequalities between the teachers and the researcher in the sense that the researcher had no link with the schools because she was not the subject advisor in these primary schools.

3.5. QUALITY ASSURANCE CRITERIA

Multiple data collection techniques, such as interviews and lesson observations, were used. The same observation protocol was used to evaluate two different lessons' observation in each case. This showed the reliability of the instrument because the information obtained in the two different presentations was more or less the same. If and when it differed, it would be because of the different teaching approaches used for a particular focus at that point in time. To ensure

the credibility of the study, the observed lessons and interviews were audiotaped. This also assisted the researcher in constantly verifying if what was recorded was indeed what transpired in the transcribed data. All these processes were conducted during a time that was convenient for the teachers.

3.6. CONCLUSION

This chapter was detailed with regard to the sampling criteria, data collection procedures, data analysis procedures. Attention was also drawn to the ethical considerations. The data collected in this study was analysed from an interpretivist perspective. A qualitative approach was used and the research design was a case study. Observations were used to determine aspects that the teachers regarded as essential and how they used these aspects to enhance teaching and learning in their classrooms. The interviews were used to triangulate information. In the next chapter, the results of the study are presented and discussed.

CHAPTER 4: DATA PRESENTATION

4.1. INTRODUCTION

This chapter reports on the findings of the teaching strategies used by three mathematics teachers who taught probability to Grade 6 learners. The three teachers are referred to as Teacher A, Teacher B and Teacher C. Data was collected through two lesson observations and one interview per teacher. The criteria used in the data observation schedule and interview protocol were adapted from the work of Antony and Wilshaw (2009), and Kvantinsky and Even (2002) (refer to Table 2.1, and Section 2.8 in Chapter 2). The four point scale that was used in the observation schedule was adapted from the National Protocol of Assessment (DBE, 2005). Each teacher presented two lessons on probability, and after the second presentation, an interview was conducted. The interview was used as a means of confirming what the teacher enacted during the lesson presentation. A summary of the interview scripts is included in the discussions.

The data will therefore be presented by first providing the demographic and general information about each teacher, followed by a presentation and analysis of data collected through classroom observations, a discussion of findings on the observed teaching and learning approaches, principles of effective teaching, and a description of the data collected through the interviews. Each case study will be narrated in terms of the findings on the observed essential aspects (essence of probability, strength of probability, different representations and models, alternative ways of approaching probability, basic repertoire, different forms of knowledge and understanding, knowledge about mathematics) and approaches used to enhance teaching (cooperative learning, discussion, and problem-based learning), with the incorporation of the principles of effective teaching.

The demographic information of the participating teachers and the general information about each school will now be discussed (see Table 4.1).

Table 4.1: Demographic and general information about each teacher

Item	Teacher A	Teacher B	Teacher C
Educational qualifications	Further Diploma in Education (Management). ACE programme in Mathematics, Science and Technology Education.	Post Graduate Diploma In Public Administration and Management; BA; BA (Hons.) Setswana, ACE programme in Mathematics, Science and Technology Education.	B.Ed. degree in Educational management; ACE programme in Mathematics Intermediate and Senior Phase.
Current school location	Rural	Rural	Rural
Gender	Male	Female	Female
Age	46	44	42
Experience (at the time of the research).	Active participant in cluster meetings.	Cluster leader for seven years. Coordinated Life Skills programmes. The HOD of Mathematics and Science Department and the chairperson of the curriculum committee.	Cluster leader for three years. Involved in music and sports.
Grades taught since appointed.	5 & 6	5 & 6	4 – 6

All three teachers had completed post graduate degrees in management. In addition to this, Teacher A and B had completed ACE programmes in Mathematics, Science and Technology Education. Teacher C took part in the ACE programme in mathematics (Intermediate and Senior Phase). None of the three teachers were studying at the time of this research. They were all experienced in the teaching of mathematics in the Intermediate Phase. All three teachers were actively involved in extra activities that support the teaching and learning of mathematics. Two of the participants were female (Teachers B and C) and one was male (Teacher A). The participating schools were located in previously disadvantaged communities in the province and included Grade R to Grade 6.

Table 4.2: General information about each school, including the dates for lesson observations

	Teacher A		**Teacher B**		**Teacher C**	
School Pseudonym	School A		School B		School C	
Date of observation	28 October		29 October		31 October	
Number of learners	35	35	40	40	38	38
Duration and time	Periods 1 & 2 (08:00 - 08: 30) (08;30-09:00)	Period 2 & 3 (09:00-09;30) (09;30-10:00)	Period 2 (09:00-10h00)	Period 1 (08:00-09:00)	Period 1 (08:00-09:00)	Period 2 (09:00-10h00)

According to CAPS (2011), probability is covered in Term 4, which is when the data for this study was collected. The complete lessons were observed in the participating Grade 6 mathematics classrooms. Table 4.2 indicates that Teacher A had 35 learners in his class, Teacher B had 40 learners, and Teacher C had 38 learners. Each teacher presented two lessons, which each lasted an hour. The first lesson for both Teacher A and B focused on understanding the language of probability, and for Teacher C, the focus was on experimental activities. The second lesson, in all three cases, focused on experimental activities like rolling a die and tossing a coin. The interview was conducted immediately after the presentation of the second lesson. The medium of instruction was English.

Each teacher had two lesson preparations for presentation on two different occasions. Teacher A used the Gauteng Primary Language and Mathematics Strategy lesson preparations (GPLMS). This strategy was introduced in the Gauteng province in South Africa to improve performance in language and mathematics in primary schools. The strategy focused on the development of lesson preparations and tasks for assessment.

Teacher B and C developed their own lesson preparations. All the lesson preparations developed by the teachers started with mental mathematics activities. Other common items included in their lesson plans were concepts and skills, a topic, resources, assessment, and concept development. The lesson preparations were relevant because all the stages of the lesson development focused on probability.

The next section presents the findings on the lessons presented.

4.2. PRESENTATION AND ANALYSIS OF THE DATA COLLECTED THROUGH CLASSROOM OBSERVATIONS

Based on the conceptual framework, the findings are now presented according to the following:

- Essential aspects in understanding and teaching probability (essence of probability, strength of probability, different representations and models, alternative ways of approaching probability, basic repertoire, different forms of knowledge and understanding, knowledge of mathematics);
- Teaching and learning approaches (cooperative learning, discussion and problem-based learning) with the incorporation of the principles of effective teaching (such as arranging learners in groups, mathematical communication, assessment for learning and worthwhile mathematical tasks).

4.2.1. Description of the data collected from the classroom observations

The purpose of the lesson observations was to explore the teaching strategies used to teach probability to Grade 6 learners. To do this, the researcher observed the following:

- How the teachers enforced the essential aspects to enhance learners' understanding of probability;
- How the teachers implemented appropriate approaches and guiding principles to enhance the teaching and learning of probability.

The data from these sources were captured using Microsoft Word, and were juxtaposed in tables to compare the findings. The tables were used to present the data because it made it easier to identify the similarities and differences amongst the three teachers in terms of how the essential aspects were enforced during the lesson presentations. Table 4.3 presents the findings and discussions on the essential aspects as observed in both lesson presentations.

Table 4.3: Essential aspects as observed in the lesson presentations

Essential Aspects	Participants
Essence of probability	**Teacher A:** The activities used by the teacher were based on objectively measurable characteristics; the approach that was assigned to an event could be repeated; the activities were also based on the subjective approach that interprets probability as the degree of belief. In the first lesson, the teacher used probability concepts to describe situations within their environment. Examples like "It is impossible that a girl can become a boy" were discussed. Experimental activities using a die were also conducted. The learners recorded the frequency of outcomes on the tally table. They were not given the opportunity to describe their subjective interpretation of the examples given, e.g. learners were not probed on responses like "I will be a teacher in 15 years' time". In the second lesson, Teacher A used playing cards to assist learners to understand the language of chance, for example, after shuffling the cards, learners responded to the question "What is the chance of picking up a black card?" They responded by saying "There are only two chances of picking a black card out of thirteen chances". The learners also represented the outcomes on a two-way table after the dice were rolled ten times. They were able to answer questions like "What chance do you have of throwing the dice to yield a total of 12?" For the subjective approach, learners were able to give appropriate examples, but were not probed to

Essential Aspects	Participants
	substantiate their responses. One learner indicated that a cow will not jump over the moon, but she was not probed to provide reasons why a cow could not jump over the moon. **Teacher B:** In Lesson 1, learners tossed a coin 20 times and recorded the results. The teacher ensured that the learners realised that the number of trials carried out correlated with the total frequency. Learners were asked to justify statements like “A brick can be broken by the wind” and “A person can sing”. One learner indicated that any person can sing because all people have a voice that can sing. Another learner said that a brick can be broken by the wind only if it is not strong. The teacher explained to the learners that it is always necessary to support their statements with reasons. The activities were based on both objectively measurable characteristics and subjective approaches. Lesson 2 focused on measurable characteristics. Learners tossed a coin 50 times and the outcomes of the experiment were recorded using a tally table. **Teacher C:** In both lessons, the teacher approached probability as an event that is repeated only. In Lesson 1, learners tossed a coin 20 times and recorded the results as shown in the table.

Essential Aspects	Participants

Outcome	Tally mark	Frequency
Head	~~1111~~ 1111	9
Tail	~~1111~~ ~~1111~~ 1	11

For Lesson 2, they tossed a coin 50 times and recorded the results of each toss on the frequency table. The groups of learners compared their results. The teacher ensured that the learners realised that the total number of frequencies was the same as the total number of tosses.

Interpretation	Teacher A and B's activities were based on both objectively measurable characteristics and subjective approaches. Teacher C's activities were based only on an objectively measurable characteristics approach. Teacher A did not probe examples given by the learners based on the subjective judgement approach, which was an aspect that was lacking. The other challenge was that teachers did not realise that the more you toss a coin, the more it becomes evident that when tossing a coin, the probability of getting either heads or tails is 50%.

Essential Aspects	Participants
Different representations and models	**Teacher A:** The outcomes in Lesson 1 were listed, described in words, and expressed in the form of a fraction, e.g. one out of six chances was written as $\frac{1}{6}$. In Lesson 2, the outcomes were also represented or expressed in percentages. **Teacher B:** The outcomes were represented in terms of percentages in Lesson 1 and in terms of the tally table in Lesson 2. The teacher asked learners to describe the following situations using the scale: Impossible (0%), Uncertain (50%), and Certain (100%). • Tomorrow I will be ill; • My sister will give birth to a baby girl; and • The chance of getting a tail when flipping a coin is 50%. **Teacher C:** Outcomes in both lessons were represented using tally tables and fractions.
Interpretation	The common model used in all three cases to represent the results of the experiments was the use of a tally table. In addition to this, Teacher A and B represented the outcomes using percentages, while Teacher A and C used factions. Other models like bar graphs and tree diagrams were not used to represent information.
Alternative ways of approaching probability	**Teacher A:** In Lesson 1, probability was defined using words. Each group of learners was provided with a dictionary to search for the meaning of probability. The learners read the meaning of

Essential Aspects	Participants
	probability from the dictionary provided and interpreted its meaning by using the words 'possible', 'certain', 'impossible' and 'uncertain'. Probability in the dictionary is defined as "the extent to which something is probable" and also as "an event that is likely to happen." No formula was used to define probability. The teacher used playing cards to explain other concepts related to probability. The teacher used a classic approach in Lesson 2 (formula for calculating probability) to define probability, e.g. one out of six chances = $\frac{1}{6}$ and explained the fraction to mean $\frac{number\ of\ desired\ outcomes}{total\ number\ of\ outcomes}$. **Teacher B:** In Lesson 1, the teacher used concepts like 'certain', 'uncertain', 'possible' and 'impossible' to define probability. She did not use any formula to define probability. In Lesson 2, the focus was on conducting experiments and recording the results. The fact that probability is defined as the value at which the relative probability stabilises when the number of experiments/trials is large enough was not emphasised. **Teacher C:** The teacher used none of the approaches to define probability in the two lessons that she presented. She represented the outcomes using fractions, but did not emphasise the use of a classic approach to define probability. The focus was more on performing experiments as stipulated in the CAPS document. The results of the experiments were recorded using tally tables. She explained probability as chance/likelihood or the possibility of

Essential Aspects	Participants
	something happening.
Interpretation	Teacher B and C did not use any of the approaches to define probability. They used probability concepts (terms) like 'certain', 'possible', and 'impossible' to define probability. All three teachers conducted experiments using both a coin and a die, whereas Teacher A went further to use cards to explain the concept of chance. The groups did not have an equal number of cards and as such the game was not fair. Some of the groups had four cards and others had six cards. He also used a dictionary to explain the meaning of probability. Above all, the teachers could not describe the relationship between probability and relative frequency. This implies that they did not realise that probability is also defined as the value at which the relative probability stabilises when the number of experiment/trials is large enough. The intention in this case was to check whether the teachers used the classic approach whereby probability is defined as $\frac{\boldsymbol{number\ of\ desired\ outcomes}}{\boldsymbol{total\ number\ of\ outcomes}}$, or if they used the approach whereby probability is defined as the value at which the relative probability stabilises when the number of experiment/trials is large enough. Probability was taught in isolation to the topic of data handling, as this was viewed by teachers to be an independent topic.

Essential Aspects	Participants
Strength of probability	**Teacher A:** This teacher highlighted the importance of probability in the two lessons and indicated how it could be practically used. Concepts were explained and connected to real-life situations. In Lesson 1, the teacher asked learners to give practical examples on how they could use probability in their everyday life. He continuously led the learners to the answers. For example, he said, "We are definitely sure that *January comes before*----------*".* He wanted learners to complete the sentence. Another example given was that "*it is sunny today"* and indeed it was a sunny day. In Lesson 2, the teacher gave learners homework to do research on the probability of getting rain the following week. **Teacher B:** The importance of probability was highlighted and it was indicated how it could be practically used. Concepts were explained and connected to real-life situations. In Lesson 1, learners were given concepts like 'certain', 'possible', 'impossible' to describe real-life situations. Examples like, *"I am certain that tomorrow is Wednesday*"; "*We are not certain that tonight we are going to have supper"*; and "*It is impossible for bread to turn into liquid"* were discussed. The focus in Lesson 2 was percentages (probability scale) to interpret real- life situations. In her presentation, she used probability concepts (terms) to predict the weather. Examples like "There is 50-50 chance of rain…" and "the probability that tomorrow will be a sunny day is 25%" were discussed.

Essential Aspects	Participants
	Teacher C: The importance of probability was highlighted in both lessons and it was indicated how it could be connected to real-life situations. In Lesson 1, the teacher asked learners to identify things that are impossible to happen and those that could possibly happen. Learners gave examples like “It is impossible for a tree to turn into a car” and “It is possible that I can go to church on Sunday.” In Lesson 2, the teacher asked learners the following question: “What is the probability that you will get married tomorrow?” The question was directed to all of the learners. The learners answered together saying that it is impossible.
Interpretation	In all three cases, the importance of probability was highlighted to the learners. The three teachers focussed on using the concepts of probability to describe situations, and the examples given were connected to real-life situations. Teacher B went further to use a probability scale in terms of percentages. The examples and activities discussed were confined only to the learners’ environment. Examples on how probability is used in areas like games, politics, business, and insurance were not discussed.
Basic repertoire	**Teacher A & C:** This aspect focused on using the terms and topics connected to probability. In both cases, probability was integrated with fractions. The outcomes of the experiments (tossing a coin and rolling a die) were represented in a fraction form, particularly common fractions, for example, Teacher A emphasised that one

Essential Aspects	Participants
	chance out of six chances can be written in a fraction form as $\frac{1}{6}$. Tallies learned in data handling were also used. In emphasising the language of probability, Teacher A used words like 'never', 'more likely', and 'almost'. Examples like "It will never happen that a person can ride a bicycle with one wheel" were discussed with the learners. **Teacher B:** The concept 'percentage' was identified and used by the teacher as related to probability. Examples like "I am 100% sure that tomorrow is Friday" were provided and discussed. This was emphasised and discussed in Lesson 2. In Lesson 1, no mathematical sub-topic was used to describe a situation, except for the use of tally tables that the learners learnt about when they were doing data handling.
Interpretation	In all three cases, the emphasis was more on doing the experiments and recording the results. The teachers did not focus much on integrating concepts within the subject. Other concepts connected to probability used are tally marks, percentages, and common fractions. The teachers, from the researcher's observation, had knowledge of the concepts related to probability, but a lot of emphasis was placed on showing how they integrated these with probability. To place more emphasis on the degree of probability, Teacher A used words like 'never', 'it will never ever happen'.

Essential Aspects	Participants
Different forms of knowledge and understanding	**Teacher A:** In both lessons, activities were based on conceptual and procedural knowledge. For procedural knowledge, experiments were conducted to lead learners towards understanding a representation of outcomes. They used dice and cards when doing experiments. For conceptual understanding, the teacher preferred that the learners understand the meaning of probability by using probability concepts to describe situations. He gave the learners dictionaries to read and discuss the meaning of probability. **Teacher B:** For procedural understanding, the teacher assisted learners with how to use a coin when conducting an experiment, for which the results of the experiment were recorded. This was done in both lessons. The other important aspect was that, in Lesson 1, the teacher used the following scenario for learners to gain an understanding of how probability concepts are used to describe real life situations and how stories could be used to explain a concept without promoting rote learning.

Essential Aspects	Participants
	The Fox and the Goat *by Aesop, a Greek writer of fables (stories which use animals and have moral)* *By an unlucky chance a Fox fell into a deep well from which he could not get out. A Goat passed by shortly afterwards and asked the Fox what he was doing down there. "Oh, have you not heard? said the Fox: "there is going to be a great draught, so I jumped down here in order to be sure to have water by me. Why don't you come down too? The Goat thought well of this advice and jumped down into the well. But the Fox immediately jumped on her back and by putting his foot on her long horns managed to jump to the edge of the well. "Good–bye, friend" said the fox, "remember next time: "never trust the advice of a man in difficulties."* *The teacher posed the following questions:* *Do you think the story is true?* *Why do you say that?* *Do you think it is impossible that such an incident would occur?* **Teacher C:** Activities were based on conceptual and procedural knowledge and understanding. The teacher developed the concepts by explaining terms like 'an outcome', 'possible', 'impossible', 'certain' and 'uncertain'. The learners conducted experiments, which lead them to an understanding of the outcomes and the representation thereof. This was also done in both lessons.

Essential Aspects	Participants
Interpretation	The teachers realised that conceptual knowledge is as important as procedural knowledge. This was evident in that the learners managed to conduct experiments that enabled them to understand the language of probability. The use of a scenario by Teacher B did not promote the memorisation of probability concepts. The use of a dictionary by Teacher A also assisted in understanding the terminology used in probability. What was most impressive was when Teacher B introduced the lesson by giving learners scenarios with a context that was accessible. She did not start by saying "What is probability?" She rather gradually assisted learners towards developing the concept of probability. None of the teachers used a spinner to conduct the experiment.
Knowledge about Mathematics	**Teacher A, Teacher B and Teacher C** This was about understanding the nature of mathematics and the concept of probability in particular. To substantiate on this, teachers were expected to have an understanding of supporting knowledge, like the fact that probability cannot be greater than 1. The teachers represented probability using proper fractions, which is of course less than 100% or less than 1. The teachers also used models like dice and coins when conducting experiments because probability as an abstract concept requires the use of models. Experiments were done several times but the teachers could not realise that in doing an experiment several times, the relative frequency will approach probability. This aspect will lead to the introduction of limits, which is covered in Grade 12 under calculus.

4.2.2. Summary and discussion of essential aspects

Table 4.3 above shed light on the extent to which the essential aspects were applied. Teachers A and B used both the subjective and experimental approaches in teaching probability. Teacher C used the experimental approach only. For the subjective approach, the teachers could not explain to the learners, for example, that the more you toss a coin the more it becomes evident that when tossing a coin several times, the probability of getting either heads or tails is 50%.

All the teachers represented the outcomes using tally tables. Moreover, Teachers A and B used percentage, and Teachers A and C used fractions to represent the outcomes. Models and representations like graphs and tree diagrams, to name a few, were not used. Teacher A used more representations than the other two teachers. During the presentation, he was guided by the GPLMS lesson preparations.

To define probability, Teacher A used a dictionary. Teachers B and C used probability concepts to describe real-life situations. The use of a dictionary was important, but the teacher was supposed to use it towards the end of the presentation as a confirmation of what the learners had discovered, not at the beginning. The teachers could not explain the relationship between probability and relative frequency to the learners. This implies that they did not realise that probability is also defined as the value at which the relative probability stabilises when the number of experiment/trials is large enough. To give an example, it becomes evident that when tossing a coin several times, the probability of getting either heads or tails is 50%.

The teachers were able to apply probability concepts to real-life situations. The challenge observed so far was that examples on how probability is used in areas like games, politics, business, and insurance were not discussed. They had

knowledge of the concepts related to probability, but emphasis was not placed on how they relate to probability.

All three teachers realised that procedural understanding is as important as conceptual understanding. Experiments that lead to the understanding of probability-based concepts were conducted. The results are in agreement with Bell *et al* (1999) who found that repetition of experiments enhanced the learners understanding of Probability. Similarly, Jones *et al* (2007) indicated that elementary learners are expected to have an understanding of terms and random events through conducting experiments. Probability-based concepts were also used to describe real-life situations. They all used proper fractions as a way of emphasising that probability ranges between 0 and 1. They also used models and different representations to simplify the abstract theory of probability.

However, Gal (2009) mentioned that learning Probability is not about conducting experiments only but is for learners to interpret situations and make predictions in real life contexts. The use of a real-life scenario was the strategy that emerged and was used to introduce the concept of probability by Teacher B. Teacher A engaged in more activities as compared to the other teachers. Probability was taught in isolation to data handling as the teachers viewed it as an independent topic. With regard to the integration within the subject, the only terms (sub-topics) that were used to describe situations were fractions and percentages.

4.3. A DISCUSSION OF THE FINDINGS ON THE OBSERVED TEACHING AND LEARNING APPROACHES AND PRINCIPLES OF EFFECTIVE TEACHING USED

This section presents the findings on the teaching approaches and principles of effective teaching that were observed. The three teaching and learning approaches (cooperative learning, discussion, and problem-based learning) were discussed in conjunction with the principles of effective teaching because these serve as vehicles for the use of the appropriate teaching approaches properly. In

other words, it means that teaching and learning approaches cannot be discussed in isolation from the principles of effective teaching.

For the purpose of this study, cooperative learning is linked to the principle of effective teaching: arranging learners in groups, discussion as a teaching approach is linked to the use of correct mathematical language, and problem-based learning is linked to assessment, as well as worthwhile mathematical tasks. This section shed more light on how the principles of effective teaching as teaching and learning approaches were applied in the teaching and learning of probability. The aim was to evaluate the extent to which they were used to make teaching and learning meaningful.

The next paragraph presents the findings on how cooperative learning was used during the presentation of the lessons.

4.3.1. Cooperative learning as a teaching and learning approach

Learners were provided with the opportunity to sit in groups and do the practical activities together. At the beginning of each presentation, learners started with written mathematics activities as individuals. They only worked in groups when doing practical activities. In other instances, some learners worked as individuals although they were seated in groups. Teacher A allocated roles to the learners when they carried out practical activities, for example, if the leader in a group rolled a die, another learner was expected to record the results. Learners took turns in rolling a die and recording the results. When interviewed, he indicated that the allocation of roles to all of the group members made learners fully engage in the activity and participate throughout the lesson presentation. Teachers B and C did not allocate roles to learners. Some of the learners were not actively involved and these teachers would then rely on other, dominant learners in the group to answer questions. Although, learners were seated in groups in the observed lessons, they were not given assignments that

encouraged collaborative problem solving activities. Stolls *et al* (2008) highlighted that group work without collaborative engagement does not allow learners to become more deeply involved in the learning process and which in turn does not improve their high order thinking skills.

Akinsola and Ifamuyiwa (2008) advocated for brainstorming as critical in initiating learning, in this study, the participating teachers did not give learners an opportunity to brainstorm the questions. When asked during the interview why this was the case, the teachers explained that is time consuming.

The learners never worked in pairs and the teachers did not create any opportunity to speak to learners individually with the aim of motivating them. Teacher A considered the mixed abilities of the learners when he placed them in groups, but Teachers B and C used a systematically random sampling method, or as it is commonly called in schools, number heads together, to form groups. 'Number heads together' means that each learner was given a number (say 1 to 8) and all learners with the number one had to move to one table, the learners with number two to the another table and so on. The teachers moved around the groups mostly when the learners performed experiments to verify if they were engaged and had the relevant resources. Due to the fact that Teacher B and C's groups were large, some of the learners did not even concentrate. The same learners responded to most of the posed questions.

The teachers maintained the same groups for both lessons. The learners never worked as sub-groups, and all of the groups focused on the same activity at the same time. As indicated earlier on in this section, cooperative learning is linked to the principle of effective teaching - arranging learners into groups. The aim of arranging learners into groups was to encourage cooperative learning amongst the learners.

Table 4.4 forms part of the discussion on cooperative learning because it shows how learners were arranged into groups.

Table 4.4: Arranging learners into groups

Principle of effective teaching	**Participant**
Arranging learners into groups	**Teachers A & C:** Learners were divided into small groups of six. **Teacher B:** Learners were divided into small groups of five.
Interpretation	All of the teachers (participants) created opportunities for learners to work in groups. Each group had both female and male learners. The groups were formed at the beginning of the year, not formed on the day of the presentation. During the interview, the teachers provided information on when and how the groups were formed.

The next sub-section presents the findings on discussion as a teaching and learning approach.

4.3.2. Discussion as a teaching and learning approach

Teacher A was able to ensure that learners were engaged in the discussions when answering some of the questions from the 2012 ANA test (an example of a question in the 2012 ANA paper is: A bag contains black and white marbles. What is the Probability of taking a white marble out of the bag without looking?"). A meaningful discussion was possible because it was a whole-class activity whereby the teacher led the discussion. At some stage, the learners were not

involved in the discussion because the kind of questions given to the learners did not warrant any discussion.

The teachers were not keen to see learners involved in a discussion, but were only interested in getting correct answers from the learners, which is in contrarily to Stolls *et al.* (2008) as they make a case for discussion as a strategy for meaningful learning. Stolls *et al* (2008) highlighted that learners should learn through their misconceptions and interact meaningfully to enhance their competences that they lose if discussions are not used as a teaching strategy .When learners gave incorrect answers, the teachers would not use this as a means of clarifying the misconceptions raised. The teachers facilitated all discussions by asking questions that would drive learners towards the correct answer. What dominated in all the lessons were the teachers' The teachers' tendency to recognise learners who raised their hands to give answers was dominant in all the observed lessons.

No opportunity was given to the learners to discuss alternative strategies with their teachers, observe alternative ways of examining a situation, learn through misconceptions, or to interact meaningfully to deepen their learning and construct knowledge.

Discussion as a teaching and learning strategy is linked to the principle of effective teaching, and mathematical language. In this instance, it was expected that learners use the correct mathematical language, which includes the use of correct probability concepts. The teachers were expected to explain the terminology to the learners to ascertain a better understanding of the concepts, and in turn the learners should have been able to use this language appropriately. This principle is very important since it serves as a vehicle to achieve the set out lesson objectives.

Table 4.5 presents how the language of probability was developed for teaching to result in meaningful learning.

Table 4.5: Mathematical language

Principles of effective teaching	Participants
Mathematical language	**Teachers A, B & C:** Activities developed by teachers for teaching and learning encouraged learners to use the correct mathematical language. Concepts like 'certain', 'uncertain', 'possible' and 'impossible' were used to describe situations. In representing the outcomes, Teacher A emphasised that the outcome $\frac{1}{6}$ should be read as 1 chance out of 6 chances. The following concepts were used in a tally table to describe the results of an experiment: outcome, tallies and frequency. The teachers encouraged the learners to communicate their ideas verbally and in writing using the language of probability.

4.4.3 Problem-based learning as a teaching and learning approach

The problem-based questions were only evident in the scenario given to learners by Teacher B (refer to the essential aspect - different forms of knowledge and understanding). In the story, the learners were able to express their thoughts about the story and provide reasons regarding their thought processes. The teacher went further to ask learners to use the word 'impossible' to describe the situation in the story. The story contained a problem-type question because it

was realistic, the context was familiar to the learners, and they were able to use the language of probability to describe the situation. The questions asked provided stimuli for learning.

The majority of the questions posed to the learners were not problem-based, and the answers given by the learners were probed to a lesser extent. No opportunity was given to the learners to critically think about the solution to a problem, nor were they allowed a chance to brainstorm on how they could use probability concepts in an unfamiliar situation. However, Trowbridge, Bybee and Powel, (2000) and Killen (1998) (as cited in Loggerenberg-Hattingh (2003) indicated that problem based learning is a process of using prior knowledge to construct new knowledge which the participants failed to do by not allowing learners to integrate the known to the unknown.

Table 4.6 presents the kind of questions that were posed during the lesson presentations, and Table 4.7 displays the assessments carried out.

Table 4.6: Worthwhile mathematical tasks

Principles of effective teaching	Participants
Worthwhile mathematical tasks **Lesson 1**	**Teacher A & C:** Both closed and open-ended questions were posed but there was no indication of fostering creative thinking. The focus was more on addressing what the policy needs. For closed-ended questions, Teacher A asked questions like: "If you roll a die, what is the probability of getting a 6?", and open-ended questions like "What is the probability that in five years you will become the president of South Africa". Teacher A did not probe the responses given by the learners to foster creative and critical thinking. 90% of the learners responded by saying that there was no chance that they would become the president of South Africa. Teacher C focused on the completion of the tally table after a die had been thrown. The learners were asked to complete the table as follows: **Outcome** | **Tally mark** | **Frequency** | | | | | | For open-ended questions, Teacher C asked learners to predict the side on which a die would fall. The learners were asked to explain what influenced their prediction. They were unable to respond and no further comments were made by the teacher.

Principles of effective teaching	Participants
	Teacher B: Both closed and open-ended questions were posed to foster critical thinking skills. The teacher asked closed-ended questions like “What comes first between Christmas and New Year” and all the learners were able to respond to this question. For open-ended questions, the teacher asked: “Why do you say it is possible to walk on the moon?” One leaner responded by saying: “There are people who have already walked on the moon”. Few learners were able to substantiate the open-ended questions posed, or examples given.
Lesson 2	**Teacher A:** Both closed and open ended questions were posed. The tasks encouraged the learners to pose problems, look for patterns and explore alternative paths. Open-ended questions were asked to foster critical thinking skills, for example, what do you mean by “your brother cannot buy a bicycle”. This question is subjective as it needed to be explained to unpack the context in which the learners gave the example. Learners were asked to choose the words that best described the results, like “The coin will always land on heads”. All the learners responded by saying it was impossible because they had seen the outcomes in doing the experiment.

Principles of effective teaching	Participants
	Teacher B & C: Both closed and open-ended questions were posed but there was no indication of fostering creative thinking. For open-ended questions, teacher B asked learners to complete the table to represent the outcomes of the results after a coin was flipped once. Teacher C also asked learners to complete the table to represent the outcomes after a die was rolled 100 times. In both cases, the learners managed to respond well to the questions because these were practical activities. For open-ended questions, Teacher B asked learners whether they were certain or uncertain that there would always be 25 hours a day. There were a few learners who responded that it would be impossible. Teacher C asked learners to indicate what the probability of rolling a 1 would be if three dice were used. Most learners could not answer this question and the teacher gave them the answe.
Interpretation	In all the three cases, he teachers used both closed and open-ended questions. Teacher C focused on the experimental activities in both lessons. Teacher A and Teacher B focused on both experimental activities and the use of probability concepts to describe situations. The leaners performed best in activities that were practical. Questions like “How can you explain the concept of probability to your parent” should be asked to foster creative thinking. This kind of question would definitely encourage learners to come up with different ways of explaining the concept of probability.

Table 4.7: Assessment of learning

Principle of effective teaching	Participants
Assessment of learning **Lesson 1**	**Teacher A & B:** No baseline assessment was conducted to check prior knowledge. Through the question and answer method, Teacher A paid attention to the correctness of the answers. If the learners gave the wrong answer, the teacher did not use this to clear up the errors or misconceptions that the learners had. Teacher B clarified the misconceptions with true/false and certain and uncertain events. She explained to the learners that the focus was not on whether the statement was true or false, but rather whether the learners were certain or uncertain that the two people had two legs. Teacher B further asked questions like "why do you say New Year's comes before Christmas?" The learners indicated that January is the first month of the year and December is the last, according to the calendar. **Teacher C:** asked learners questions based on the work done in the previous lesson. The work focused on defining perimeter, volume, and capacity. This was in no way linked to the presented lesson on probability.
Lesson 2	**Teacher A, B, and C:** All the teachers gave learners written work in class. This classwork in each case was marked and feedback was given to the learners immediately. Teacher A started by drawing the tally table that had been discussed the previous day on the board, and no questions were asked.

Principle of effective teaching	Participants
	The learners wrote down the classwork on determining the probability of an event. An example of a question asked is as follows: “A bag contains seven black and 4 white marbles. The Probability of taking a white marble out of the bag without looking is_____” and feedback was given to the learners immediately. This question comes from the 2012 ANA test paper. Teacher B gave learners classwork on recording the results of experiments using the tally table. The activities were marked and feedback was immediately given to the learners. Teacher C gave learners classwork on indicating the probability of rolling a 4, 5 and 6 if three dice are used.
Interpretation	The teachers used informal assessments to inform the teaching and learning. The learners wrote down the classwork, and at some stage some of the teachers used a question and answer method to check the leaners’ understanding. Questions asked in all the cases were relevant to the topic, except for the baseline assessment conducted by Teacher C. Teacher C did not dwell much on the concepts involved in probability. She focused on the experimental activities in both lessons.

4.4. DESCRIPTION OF THE DATA COLLECTED THROUGH THE INTERVIEWS

4.4.1. Post-lesson interviews with the participating teachers

In this section, a full description of the interviews conducted with the participating teachers will be presented with reference to the principles of effective teaching as proposed by Antony and Wilshaw (2009, p. 7-26), and on the model in the framework for teacher knowledge and understanding of probability, as proposed by Kvantinsky and Even (2002, p.1) (see Table 2.1 and Section 2.8 in Chapter 2). Interviews were conducted and triangulated with the lesson observations. Interviews were chosen because "it allows the researcher to remain flexible, to permit participants to express their opinions, concerns, and feelings so that important information can still arise" (Leedy & Ormrod, 2001, p. 67).

All excerpts of the interviews held with Teacher A, Teacher B and Teacher C are referred to as Appendices G, H and I respectively. The interviews focused on the teachers' experiences in teaching mathematics, teaching and learning probability, reflecting on the lessons presented, and the discussion in this section is presented as such.

4.4.1.1. Discussion of the findings of the post-lesson interview with Teacher A

Teacher's experiences in teaching Mathematics

It is noted that Teacher A was well experienced in terms of teaching mathematics because he taught mathematics in Grade 6 for more than five years. He rated data handling as the second preferred topic to teaching mathematics and regarded classwork, homework, support activities and prior knowledge as basic elements that should be considered in planning a lesson. He appreciated the importance of the workshops that he attended, but further indicated that none of the workshops focused on probability. This teacher emphasised that lesson preparations are important to guide teaching.

Teaching and learning probability

With regard to teaching and learning probability, the teacher emphasised that learners learn best by listening, doing activities practically, and by working in groups. To support this, when the learners were engaged in practical activities, this teacher ensured that each learner had a role to play. He also highlighted that he used the readily available lesson plans because they were developed in line with CAPS.

Reflection on the lessons presented

The teacher indicated that he wanted learners to be able to explain the concept of probability, to conduct experiments and to be able to use probability concepts in real-life situations. He also acknowledged the fact that he needed to review some of his teaching strategies.

4.4.1.2. Discussion of findings of the post-lesson interview with Teacher B

Teacher's experiences in teaching mathematics

Teacher B was well experienced in terms of teaching mathematics because she had taught it for more than five years. In terms of the order of preference in teaching the topics, she ranked data handling as number one. She regarded the problem solving strategy, topic, resources, and assessment as basic elements that should be considered in planning a lesson. She further indicated that she had never attended any workshop on probability.

Teaching and learning probability

With regard to teaching and learning probability, the teacher emphasised that learning only becomes meaningful if the approach used is learner-centred and if it is contextualised. This was evident when she used a scenario to introduce the concept of probability. The learners analysed the story and answered the questions that were posed. She indicated that CAPS emphasises the use of experiments in teaching and learning probability, and she therefore regarded the use of resources as important to make learning meaningful.

Reflection on the lessons presented

The teacher was confident in indicating that she would still teach the lessons the same way if given the chance to teach the topic again. This response was interpreted to mean that she regarded her lesson presentation to be excellent. During the interview, she clearly stated that she did not have any weakness with regard to the teaching of mathematics, particularly probability. She also wanted learners at the end of the year to have mastered the language of probability. In all the activities, the teacher encouraged the use of correct mathematical language; this included the use of probability concepts when describing real life situations.

4.4.1.3. Discussion of the findings of the post-lesson interview with Teacher C

Teacher's experiences in teaching mathematics

Teacher C was well-experienced in terms of teaching mathematics because she had been teaching mathematics in Grade 6 for more than five years at the time of this study. She ranked data handling as the last preferred topic to teach in mathematics and regarded topic, time, content, strategy for grouping learners, as well as assessment as basic elements that should be considered in planning a lesson. She indicated that she never attended any workshops on probability. She considered the teaching of probability as important because it enables learners to predict what will happen in the future. She emphasised that lesson preparations are important to guide teaching.

Teaching and learning probability

With regard to teaching and learning, the teacher emphasised that learning would only become meaningful if learners were involved. This was evident when the teacher involved learners during the presentation of the lesson, particularly when they conducted experiments. She highlighted the fact that the approach to teaching probability, strategies or the techniques used plays a very important role in helping learners to construct knowledge. To give an example, the teacher indicated that in teaching mathematics, she preferred to use bright colours.

Reflection on the lessons presented

The teacher indicated that her lessons were aimed at ensuring that learners are able to perform experiments and record the results. Like other teachers, she has also indicated that she had never attended any workshop on probability.

4.4.2. Summary and discussion on the interview responses for the three participating teachers

Teachers' experiences in teaching mathematics

All the teachers had more than five years' experience in teaching Grade 6 mathematics. Teacher A ranked data handling at number two, Teacher B, number one, and Teacher C ranked it to be last. They commonly regarded assessment as one of the most important aspects to be considered in planning a lesson. In interacting with these teachers, the researcher realised that they regarded essential aspects as any approach that could make learning meaningful. The teachers also highlighted that it is important to plan a lesson because it guides the lesson presentation and assists the teachers not to lose focus. Lastly, all three teachers indicated that they had never attended a workshop on probability.

Teaching and learning probability

With regard to teaching and learning probability, the teachers emphasised that learners learn best by listening, doing activities practically, working in groups, when they are involved, and when learning is contextualised. This is supported by the fact that learners were seated in groups, conducted the experiments using coins and dice, and activities done were connected to real-life situations. However, being seating in groups did not benefit them that much because the teachers did not create opportunities for learners to interact and learn from each other.

Reflection on the lessons presented

Teacher A and B indicated that their intention was to ensure that learners understand the language of probability, and Teacher C explained that she wanted to ensure that the learners performed the experiments and were able to record the results. In terms of improving the teaching of probability in future lessons, Teacher A indicated that he needed to review the strategies involved, and Teacher C stated that she needed to attend workshops on how to teach probability. Teacher B confidently indicated that she did not have any challenges in teaching probability, she would still teach it the same way given a chance to teach the lesson again.

4.5. CONCLUSION

In this chapter, the results of the three cases were presented. The study revealed that the participating teachers were well experienced in the teaching of mathematics and taught the subject with passion. This is because they managed to use various strategies in teaching probability. The use of strategies in this instance meant that the teachers reinforced essential aspects with appropriate teaching and learning approaches. Although this was the case, their knowledge of teaching and learning approaches was limited. The data was collected by means of two lesson observations per teacher with one semi-structured interview being conducted after the second lesson presentation. The data collected through the interview confirmed what was observed during the lesson presentation, except in a few items.

All three teachers managed to achieve their objectives. Teacher A was quite proficient in the sense that he used many strategies to teach probability. For informal assessment, he took some of the questions from the 2012 ANA test. He also had more resources than the other teachers. The only challenge was that he did not distribute an equal number of cards to the different groups, which made the game unfair. The GPMLS lesson preparations might have also been helpful to Teacher A.

During the interview, they indicated that they attended several workshops, except the one on teaching probability. Teachers still have challenges in implementing the appropriate teaching and learning approaches to result in meaningful learning.

In the next chapter, a discussion and summary of the findings from this chapter will be presented, the research questions will be answered, the limitations of the study will be discussed, and recommendations for further study will be provided. The findings are discussed and summarised under the following themes:

Theme 1: Teachers' knowledge and understanding of probability; and
Theme 2: The effective use of appropriate teaching approaches.

CHAPTER 5: SUMMARY AND CONCLUSION

5.1. INTRODUCTION

This chapter aims to provide a summary of the findings from the three case studies in relation to the main research question, and to state final conclusions. The similarities and differences displayed by the three participating teachers with regard to their teaching strategies are highlighted in accordance with the framework that guided the study.

Two themes that were presumed to have an impact on the effective teaching of probability to Grade 6 learners were identified after the literature study, namely: teachers' knowledge and understanding of probability; and the effective use of appropriate teaching approaches.

The first theme, which comprises seven essential aspects (essence of probability, strength of probability, different representations and models, alternative ways of approaching probability, basic repertoire, different forms of knowledge and understanding, knowledge of mathematics) endeavours to answer the first secondary research question: How do teachers enforce the essential aspects to enhance learners' understanding of probability? This theme focused on the teachers' knowledge and understanding of probability.

The second theme aimed to find the answers to the second secondary research question: How do teachers implement appropriate approaches and guiding principles in teaching probability? This second theme focused on the effective use of appropriate teaching approaches.

This chapter is based on a discussion of these two themes, the limitations of the study, and recommendations for further studies. The aim of the study was to explore the effectiveness of the teaching strategies used by the three participating teachers in teaching probability.

5.2. CONCLUSION OF TERMS WITHIN THEMES

5.2.1. Teachers' knowledge and understanding of probability

This theme is divided into seven aspects, viz. essence of probability, strength of probability, different representations and models, alternative ways of approaching probability, basic repertoire, different forms of knowledge and understanding, as well as knowledge of mathematics. The discussion of findings on this theme is based on evidence from the observed lessons and the discussions with the teachers during the individual interviews.

5.2.1.1. Essence of probability

This aspect explored teachers' use of objective and subjective approaches in teaching probability. An objective approach, in this context, is an approach "that is assigned to an event that can be repeated and a subjective approach describes probability as the degree of belief, rather than the relative occurrence" (Kvantinsky & Even, 2002, p.2).

In all the cases, the teachers used an experimental approach to explain the language of probability. In relation to the approaches described in the previous paragraph, all the teachers' activities were based on the objective approach. They conducted experiments using the coins and dice. The experiments were conducted several times and the outcomes were listed and represented on tally tables. Teacher A and B's activities were also based on the subjective approach. In the case of the subjective approach, the learners used probability concepts to describe real-life situations.

This aspect was partially demonstrated because learners would give examples that interpreted probability as the degree of belief, but they were not probed to provide reasons for such statements or examples. In all three cases, when experiments were conducted, the teachers focused more on recording the outcomes than assisting learners to realise that the value at which the relative frequency stabilises is probability.

5.2.1.2. Strength of probability

The teachers gave examples where probability concepts were applied to real-life situations. The learners, in turn, were able to apply what they learnt in class to their everyday lives. In all three cases, learners used concepts of probability to describe situations within their environment. Examples like *"What is the probability that you will get married tomorrow?"; "There is 50-50 chance of rain…";* "*It is sunny today";* "*We are not certain that tonight we are going to have supper"* and "*It is impossible for bread to turn into liquid"* were given and discussed *(cf. Table 4.3).*This aspect was well-demonstrated in terms of connecting probability to real-life situations, however, examples on how probability could be used in areas like games, business, politics, and insurance should have been discussed to expose learners to other situations apart from the environment in which they found themselves.

5.2.1.3. Different representations and models

It was observed that all the teachers used tally tables in recording the results of the experiments. This is in line with what has been stipulated under content clarification in CAPS (see Section 2.3.2). In addition to this, Teacher A expressed the results in percentages and fractions, Teacher B in percentages only, and Teacher C in a fraction form. The teachers were also expected to use graphs because the graphs were dealt with in data handling in Grades 4-6, particularly the bar graphs. Although the bar graphs were not specifically prescribed under probability, graphs could be analysed and interpreted, which could assist learners to predict what could happen in future. This aspect was fully demonstrated.

5.2.1.4. Alternative ways of approaching probability

The emphasis on this aspect was on how probability was defined. The intention, in this case, was to check as to whether the teachers used a classic approach whereby probability is defined as $\frac{number\ of\ desired\ outcomes}{total\ number\ of\ outcomes}$ or if they used an approach whereby probability is defined as the value at which the relative probability stabilises when the number of experiments/trials is large enough.

All three teachers used probability concepts like ‘certain’, ‘uncertain’, ‘impossible’, and ‘possible’ to describe situations as a way of defining probability. Teachers B and C did not use any of the approaches to define probability. Teacher A asked learners to read and discuss the meaning of probability from the dictionary. Moreover, Teacher A asked learners to answer the question: “What is the probability of getting an even number when a die is thrown?” Leaners gave $\frac{3}{6}$ as an answer. The teacher explained that the answer represented the ratio of the desirable outcomes to the total number of outcomes.

This aspect was partially demonstrated because these teachers did not realise that the aim of conducting an experiment is to show that the value at which relative frequency stabilises when the number of trials is large enough is called probability.

5.2.1.5. Basic repertoire

Teachers A and C integrated probability with fractions. When expressing an outcome as a fraction, Teacher A would always emphasise how a fraction should be read. For example, one sixth was read as one chance out of six chances, which meant that the desirable outcome was read as relative to the possible number of outcomes. Teacher B integrated probability with percentages when presenting her lessons. Teacher C used tallies that learners learnt in data handling to represent the results of the experiments. Teachers should be encouraged to provide more examples of supporting knowledge.

5.2.1.6. Different forms of knowledge and understanding

The researcher looked at how the teachers displayed their understanding of probability concepts (mastery of probability concepts) and the procedures used to unpack these concepts (how probability concepts are developed).

The three teachers used the language of probability to describe real-life situations. They ensured that the learners were able to conduct experiments as one of the techniques that could be used to develop probability-based concepts. In explaining probability concepts, they also provided appropriate examples to show their mastery of the concept.

The use of a scenario (story) by Teacher B also served as an example to show that the teachers had different ways of developing the concept (procedure). Furthermore, Teacher A ensured that the meaning of probability was well-understood by letting learners read and discuss its meaning from the dictionary. This aspect was evident in the teachers' lesson presentations.

5.2.1.7. Knowledge of mathematics

Mathematics is a special subject that uses symbols and notations to describe relationships. Teachers A and C used fractions, and Teacher B used percentages to describe situations. All the teachers used tally tables to represent outcomes. These activities were used to build awareness of how mathematical relationships could be used in social and environmental relations.

Teachers A and C had an understanding of supporting knowledge because, during the lesson presentations, they emphasised that probability cannot be greater than 1. This is why they represented the outcome as a proper fraction. Teacher A also used a die, coin and playing cards when conducting experiments to explain probability concepts, because probability as an abstract concept requires the use of models. This aspect was evident when the lessons were presented.

5.3. CONCLUSION IN TERMS OF THE RESEARCH QUESTIONS

5.3.1. Secondary research question 1

How do teachers enforce essential aspects to enhance learners' understanding of probability?

This question was aimed at revealing how the essential aspects were enforced in the teaching and learning of probability. The study revealed that the essential aspects, knowledge of mathematics and different forms of knowledge and understanding, were fully demonstrated during the presentation of lessons. Fully demonstrated means that the manner in which the activities were done during the lesson presentation reflected the nature of the essential aspects.

A brief discussion on how each of the following essential aspects was lacking in the teachers' lesson presentations is presented as follows:

- **Essence of probability**: Learners were never given the opportunity to describe their subjective interpretation of the examples discussed during lesson presentations.
- **Alternative ways of approaching probability:** The teachers did not realise that the value at which relative frequency stabilises when the number of trials is large enough is called probability.
- **Knowledge of mathematics:** Experiments were conducted several times but the teachers were unable to explain that in performing the experiment of an event several times, the relative frequency approaches probability.

Alternatively, although the following aspects were evident during the presentation of the teachers' lessons, I would still recommend that, in all cases, the teachers improve on the following aspects:

- **Different representations and models:** To show the connectedness of mathematical concepts, the teachers could have thought of analysing and interpreting graphs, which would ultimately assist learners in predicting what could happen in the future. Graphs were dealt with in the Intermediate Phase under data handling.
- **Basic repertoire.** More examples of supporting knowledge to explain the concept of probability should be given.

Another important finding is that the teachers regarded essential aspects as anything that could make a lesson a success, starting from the items that should be in the lesson preparation up to the approaches used in presenting mathematics lessons. With regard to the resources used in teaching probability, the same resources that were identified in the literature (coins and dice) were used by the three teachers, except spinners. To support this argument, Jones *et al.* (2007) argue that elementary learners are expected to have an understanding of chance and random events through conducting

experiments by using resources like dice, coins, and spinners. The challenge was that the teachers in this study could not use spinners due to time constraints.

According to Wessels and Nieuwoudt (2011), teachers in primary and secondary schools are not well-grounded in probability and this limits their confidence and competence in teaching the concept. They further indicate that anecdotal evidence suggests that probability is not taught in many schools and some regard it as unimportant and thus do not teach it.

Although these three situations could not be extrapolated to other situations, it is assume that other schools also teach this concept. The reason for this assumption is that schools are provided with an annual teaching plan by the provincial Department of Education. The plan covers probability as one of the topics that should be taught. Alternatively, the end-year examination paper is set at provincial level. The developers of question papers are guided by the annual teaching plan and CAPS, and they therefore also include probability in the examination paper.

The next section will focus on the teaching approaches used bythe teachers when teaching probability to their Grade 6 learners.

5.3.2. Secondary question 2

How do teachers implement appropriate approaches and guiding principles in teaching Probability?

The purpose of this question was to reveal how the three teachers used the appropriate teaching approaches to enhance learners' understanding of probability. This theme is discussed under the teaching and learning approaches: cooperative learning, discussion, and problem-based learning.

The teaching and learning approaches are interdependent to result in a meaningful learning opportunity. This means that the practice of one approach leads to the introduction of another or incorporates the other. Furthermore, a discussion of the

principles of effective teaching will be infused in this section because they serve as the vehicle for the effective use of these teaching and learning approaches.

Discussion forms part of the cooperative and problem-based learning approaches. In other words, learning becomes meaningful if discussion is encouraged amongst learners. In support of this statement, cooperative learning is about how learners work together and benefit from discussions with each other, while problem-based learning is about analysing and discussing contextual questions. Although it was discussed separately, discussion is always integrated with the other teaching and learning approaches, and therefore plays a very important role in any teaching and learning situation.

5.3.2.1. Cooperative learning

In all cases, learners were provided with the opportunity to sit in groups that were maintained throughout the two lessons presented. For the grouping style, Teacher A considered mixed abilities. Teachers B and C used numbers to divide learners into groups. Teacher A allocated roles to learners in each group when they conducted experiments. Teachers B and C did not allocate any roles to learners. The teachers, in all three cases, did not create opportunities for learners to work in pairs or sub-groups.

Akinsola and Ifamuyiwa (2008) indicate that cooperative learning can serve the purpose of tutoring, remediation, enrichment and brainstorming. From the evidence gathered during this study, this did not happen because in none of the three cases was an opportunity created to have discussions in their groups. Learners with complementary strengths were never paired. The teachers never talked to learners individually as a way of motivating them either.

Balasooriya *et al.* (2010) advise that to foster a productive learning environment, teachers have to allocate roles to learners, and allow learners to lead an activity. In addition to this, Fuentes (2013) encourages teachers to ensure that there is quality of discussions in small groups, and to redefine classroom norms and roles to enhance learners' mathematical understanding.

Only Teacher A managed to allocate roles to learners and the class was active throughout the presentations, but learners were not given the opportunity to take the lead in the activity. This was only done for practical activities. No opportunity was ever created for learners to brainstorm ways of solving problems together as a group. Cooperative learning in this case was partially implemented.

5.3.2.2. Discussion as a teaching and learning approach

Most of the activities done with the learners did not warrant discussion. Activities were in the form of questions and they focused mainly on the use of probability concepts to describe situations. In other words, the learners did not engage in discussions within their groups. The questions posed were mostly closed–ended. This type of question did not encourage learners to engage in analysing a problem, which would automatically lead to the discussion of how a problem should be solved.

No opportunity was given to learners to discuss alternative strategies with their teachers, observe alternative ways of examining a situation, learn through misconceptions, or to interact meaningfully to deepen their learning and construct knowledge. It was difficult for the learners to learn from each other because discussions amongst group members did not take place. The teachers had insufficient knowledge of how to implement this teaching and learning strategy.

5.3.2.3. Problem-based learning

De Graaf and Kolmos (2003, p.658) describe problem-based learning as an approach that promotes students' motivation and comprehension. In all three cases, the teachers asked questions that were practical, realistic and the context was familiar to the learners. Learners were able to apply what they had learnt within their environment. Teachers A and C predominantly used closed-ended questions, whereas Teacher B also asked closed-ended questions but in one instance she used a scenario wherein learners were expected to read and critically analyse the story to answer the questions

posed. The questions served as stimuli for the learners' critical thinking in the learning process.

The closed-ended questions used focused mainly on probability concepts like 'certain', 'uncertain', 'possible' and 'impossible' to describe real-life situations. These kinds of questions did not promote learners' critical thinking, but were posed for learners to understand the language of probability.

A brief discussion on how each of the following teaching and learning approaches was lacking in the teachers' lesson presentations is presented as follows:

- **Cooperative learning:** learners were seated in groups but were never given the opportunity to take the lead in the activities and to interact with each other.
- **Discussion**: The discussion between the teacher and the learners was minimal. It happened only when instructions were given and clarified. It never happened amongst learners. The lesson presentations did not encourage learners to learn through misconceptions. The use of correct mathematical language was encouraged.
- **Problem-based learning:** The predominantly asked questions were closed-ended and did not serve as stimuli for learners' critical thinking in the learning process. Problem-based questions were not asked to develop the skill of understanding and resolving a problem. The learners did not discuss alternative ways of examining a solution with their teachers. The findings are in agreement with the proposal of Gür and Kandermir (2009) that more research should be conducted on developing appropriate tasks to develop learners' critical thinking.

5.3.3. Primary research question

What are the teaching strategies used by mathematics teachers to teach Grade 6 learners probability?

The assumption made in this study was that Intermediate Phase teachers do not have adequate content knowledge (CK), as well as knowledge of the appropriate strategies to successfully teach probability to Grade 6 learners. Based on the findings of this study, the three teachers had knowledge of how the concept of probability should be unpacked because they managed to achieve their objectives, although some of them were only partially achieved. To provide an example, according to the literature, learners in primary schools are expected to use the terms 'predict' and 'possibility' to unpack probability-based concepts, but the teachers emphasised the latter and it sounded too abstract for the learners. To place more emphasis on this argument, probability is not about doing an experiment, but rather about interpreting situations and making some predictions in real-life situations. Alternatively, none of the teachers used spinners to conduct experiments; hence the objectives were only partially achieved.

To answer the main research question, this study found that the strategies used by the participating teachers are as described in Section 5.2. This implies that they used the appropriate teaching and learning approaches to enforce the essential aspects, however, their knowledge on how teaching and learning approaches should be implemented was limited.

5.4. LIMITATIONS OF THIS STUDY

The following limitations emerged during the current study and the researcher thus attempted to accommodate them.

- Since this study was based on a qualitative approach, the three case studies from three circuits cannot be extrapolated to the entire country.

- Moreover, the sample included Grade 6 learners only. This might not give a clear picture of what the situation is with regard to the teaching of probability in the Intermediate Phase.

  Regarding the observed lessons in this study, the observational situation was not real, as the teachers had to make thorough preparation, unlike when a visit to a school is unannounced.

5.5. RECOMMENDATIONS FOR FURTHER STUDY

Based on the findings of this study, it has been noted that teachers teach mathematics concepts based on how they interpret the concepts and skills to be developed and the knowledge that they have with regard to teaching strategies. A good knowledge and application of teaching approaches, and correct interpretation of the skills to be developed will result in the successful teaching of probability. A study to investigate how probability is taught in different grades (Grades 4-6) is recommended; the reason for this being that the concepts and skills are the same, and teachers could not cover the Grade 6 content in two hours.

Teachers should explore probability further by analysing the curriculum for the Senior and FET phases. The reason for this is that teachers need to lay a proper foundation that will assist learners in the next phase. One other aspect that was observed was that in their lesson preparations, none of the teachers allocated time for reflection, which is vital in the construction of learners' learning. Thus, it is recommended that this be included in the teaching of probability in the mathematics classroom.

A crush/short course training that will develop teachers' skills on designing questions, facilitating discussions and the extent to which cooperative learning should take place is also recommended.

5.6. CONCLUSION

A qualitative research approach using an interpretive case study was conducted. A conceptual framework to guide the study and assist in data collection and data analysis was developed from the literature. Data was collected using an observation protocol

and interview schedule. The data collected was triangulated through interviews after the second lesson was presented in each case.

The study effectively investigated the strategies used by teachers to teach probability to Grade 6 learners. The teachers who participated in this study were selected based on their performance for the past three years and their background relating to their experience in teaching mathematics.

The findings in this study indicated that the practice that the teachers displayed in this study lacked the depth of some of the essential aspects and the proper implementation of the teaching and learning approaches.

In conclusion, these three teachers were well experienced in the teaching of mathematics, and portrayed sound knowledge of mathematics, however, they still needed to explore more on how to use the approaches that will result in meaningful learning. Their effective teaching in mathematics could generally be linked to the following:

- Experience in teaching mathematics and the qualifications that they had;
- The use of practical activities to explain the language of mathematics;
- The use of scenarios to contextualise learning; and
- The use of teaching models to simplify abstract theory.

I would also regard teacher A as a proficient teacher because he managed to use various strategies to develop the concept of probability. In addition to this, he was the only teacher who used the questions in the previous ANA paper to assess his standard of teaching. One other factor that contributed to his approach of teaching probability was the use of the GPLMS lesson preparations. This was an instance where meaningful discussion took place amongst learners because he facilitated the activity.

The extra information that was gained in this study is that:

- Essential aspects are applicable to primary schools, although there are few exceptions that are not applicable, like using and understanding formulae, as expected in secondary schools;
- If all the essential aspects could be enforced fully, the learners would understand the nature of probability;
- The use of the conceptual framework assisted the researcher in understanding the nature of probability; and
- The participating teachers regarded strategies as any technique or approach that could make a lesson meaningful and successful.

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APPENDIX A: CLASSROOM OBSERVATION PROTOCOL

Subject: Mathematics **Topic**_____ **Date:** _____**Duration**: _____. **Grade**: 6

Teacher Name (pseudonym):_____ **Gender:**_____ **Number of learners**: ____

Observer Name: **Site/Venue**_____

RESEARCH TITLE: Teaching strategies used by mathematics teachers to teach Grade 6 Probability in Nkangala District

RESEARCH TOPIC: What are the teaching strategies used by mathematics teachers to teach Grade 6 learners Probability?

_____

Brief overview: Probability is described as a yardstick for measuring uncertainties in the occurrence of events when the outcomes are not predetermined. Its importance emanates from the fact that the world is full of uncertainties. In order to understand our world, we must be able to interpret these uncertainties. The purpose of this study is to explore the strategies used by mathematics teachers to teach Grade 6 learners Probability. The researcher and the supervisors will be the only people that have access to the data.

PART A: PRINCIPLES OF EFFECTIVE TEACHING

PRINCIPLE 1: **ARRANGING GROUPING STRATEGIES FOR LEARNING**				
	1	2	3	4
	No grouping of learners	Create opportunities for learners to work in small groups only	Create opportunities for learners to work in pairs	Create opportunities for learners to work in pairs and small groups
	Comments			

	TEACHING AND LEARNING APPROACH: COOPERATIVE LEARNING			
	1	2	3	4
	Learners did not work as a group	Learners work as a group, but roles were not allocated to group members	Learners work as a group for a particular activity and roles were allocated to group members	Learners work as a group throughout the presentation and roles were allocated to group members a
	Comments			
PRINCIPLE 2: WORTHWHILE MATHEMATICAL TASKS				
	1	2	3	4
	Tasks posed encourages memorisation	Only closed ended tasks are posed	Only open-ended questions are posed	Tasks encourage learners to pose problems, look for patterns and explore alternative paths. Open-ended tasks to foster creative thinking skills
	Comments			
PRINCIPLE 3: ASSESSMENT FOR LEARNING				
1		2	3	4
Do not ask questions during the presentation to get feedback from learners		Asks questions and pays attention to the correctness of an answer	Ask questions and pays attention to the correctness of an answer and learners' mathematical thinking	Ask questions and pays attention to the correctness of an answer, and learners' mathematical thinking and always give feedback to clear the misconception
Discussion				

TEACHING AND LEARNING APPROACH: PROBLEM-BASED LEARNING			
1	2	3	4
Problems given to learners not practical	Problems given to learners practical, context familiar to learners	Problems given to learners practical, context familiar to learners and promote critical thinking	Problems given to learners practical, context familiar to learners ,promote critical thinking and provide stimuli for learning
Comments			
Principle 4: Mathematical Language			
1	**2**	**3**	**4**
Encourage learners to use the correct mathematical language to communicate their ideas verbally and use the correct mathematical language	Encourage learners to use the correct mathematical language to communicate their ideas in writing	Encourage learners to use the correct mathematical language to communicate their ideas verbally and in writing	Encourage learners to use the correct to communicate their ideas orally, in writing , and using various representations
Comments			
TEACHING AND LEARNING APPROACH: DISCUSSION			
1	**2**	**3**	**4**
Did not encourage learners to discuss amongst themselves	Learners discuss alternative ways of examining a solution	Learners discuss alternative ways of examining a solution and the teacher gives proper guidance	Learners discuss alternative ways of examining a solution, how a solution should be solved and the teacher gives proper guidance

Discussion				
***PART B*: ASPECTS OF TEACHER SUBJECT KNOWLEDGE AND UNDERSTANDING OF PROBABILITY**				
Aspect 1: **Essence of Probability**				
	1	2	3	4
	Probability is not assigned to either objective or subjective approach	Probability is assigned to a one-time event and hence based on the subjective judgement made by the individual	Probability is assigned to an event that is repeated and hence based on the objectively measurable characteristic	Probability is assigned to both one-time and repeated events
	Comments			
	Aspect 2: Strength of probability			
	1	2	3	4
	The importance of Probability was not highlighted	The importance of probability was highlighted by giving examples to describe real-life situations	The importance of probability was highlighted by giving examples to describe real-life situations and mathematical notations were used	The importance of probability was highlighted by giving examples to describe real-life situations, not only within their environments, and mathematical notations Were also used
	Comments			

	Aspect 3: **Different representations and models**			
	1	2	3	4
	Describes the results of experiments verbally	Lists outcomes for the experiments conducted	Uses tables and tallies to record results of the experiments	Uses various representations and models to record the results of the experiments
	Comments			
	Aspect 4: **Alternative ways of approaching probability**			
	1	2	3	4
	Uses neither of the approaches to define probability	Uses the classic approach (formula for calculating probability) to define probability	Uses experimental (the value at which relative probability stabilises) approach to define probability	Uses both experimental and classic approaches to define probability
	Comments			
	Aspect 5: Basic repertoire			
	1	2	3	4

	Teach probability in isolation to other mathematical concepts	Can identify topics and sub-topics related to probability and did not connect them to Probability	Can identify topics and sub-topics related to probability, and connected them to Probability	Can identify topics and sub-topics related to probability, and connected them to Probability. Used powerful examples to illustrate important ideas.
	Comments			
	Aspect 6: Different forms of knowledge and understanding			
	1	**2**	**3**	**4**
	Activities are based on the use of formal rules	Activities are based on conceptual knowledge and understanding	Activities are based on procedural knowledge and understanding	Activities are based on conceptual and procedural knowledge and understanding
	Comments			
	Aspect 7: **Knowledge about Mathematics**			
	1	2	3	4
	No use of supporting knowledge to	Uses models and experimentation as supporting knowledge to	Uses models and experimentation as supporting knowledge to explain probability concepts.	Uses models and experimentation as supporting knowledge to explain probability concepts. Emphasised the nature of

	explain probability concepts	explain probability concepts		Probability
	Comments			

Overall Comment/Remarks

_____

_____

Observer's signature:_____ Date: _____

Note:

- Principles 1- 4are adapted from Antony & Walshaw(2009, p. 7-26)
- Aspects 1-7 in the above rubric are adapted from the article titled "The Framework for teacher knowledge and understanding about probability" as proposed by Kvantinsky and Even (2002:1)
- The four point scale rubric is adapted from the rubrics used by the National Department of Education for Assessment.
- The comment section will take note of anything that the teacher does which is not included in the rubric.

APPENDIX B: INTERVIEW SCHEDULE WITH THE EDUCATOR

RESEARCH TITLE: Teaching strategies used by mathematics teachers to teach Grade 6 Probability in Nkangala District

RESEARCH QUESTION: What are the teaching strategies used by mathematics teachers to teach Grade 6 learners Probability?

_____

Interviewee:_____Gender:_____Place/site/venue:_____

Date:_____ Time of interview:_____ Duration: _____

Brief overview: Probability is described as a yardstick for measuring uncertainties in the occurrence of events when the outcomes are not predetermined. Its importance emanates from the fact that the world is full of uncertainties. In order to understand our world, we must be able to interpret these uncertainties. The purpose of this study is to explore the strategies used by mathematics teachers to teach Grade 6 learners Probability. The researcher and the supervisors will be the only people that have access to the data.

Post-lesson interview questions

PART A: GENERAL QUESTIONS	
Question posed by the researcher	**Response**
How many years of experience do you have teaching Mathematics to Grade 6 learners?	
Rank the content areas to indicate the order of preference. The order should indicate your strength from good to not comfortable	
Can you briefly tell us about the mathematics workshops that you attended?	
Do you normally prepare a lesson before presenting it to learners and why?	
What basic elements did you consider important in planning the lesson you presented?	
PART B: QUESTIONS RELATED TO TEACHING AND LEARNING	
What are your strengths and weaknesses (challenges) with regard to facilitating a lesson on probability?	
What necessary and appropriate resources do you use to effectively present your lesson?	
What do you think usually prevents learners from achieving the intended outcomes. How, can you address this challenge?	

To what extend do you consider the teaching of probability important?	
Which aspects do you consider essential in the teaching of probability?	
To what extend do you consider the use of different teaching strategies important?	
What teaching strategy do you use to make your lesson very interesting?	
How do you check learners' understanding during the presentation of your lesson?	
Describe the level of emphasis that CAPS placed on probability?	
PART C: REFLECTION ON THE LESSONS PRESENTED	
What were the outcomes of your lesson?	
Why did you choose to structure the lesson the way it was structured?	
How can you improve the teaching of probability in your future lessons?	
Thank you for your thoughts, time and effort in participating in this research study	

END OF THE INTERVIEW

APPENDIX C: LETTER TO REQUEST PERMISSION TO CONDUCT RESEARCH

The Circuit Manager

Nkangala District

---------- Circuit

Subject: Request to conduct a research in schools from your circuit

Dear sir/madam,

I am currently enrolled for an M.Ed. (General) in Mathematics, Science and Technology Education at the University of Pretoria. I would like to request your permission to undertake a research study in ----------school, from your circuit.

My research topic is: **Teaching strategies used by mathematics teachers to teach Grade 6 probability in Nkangala District.** The purpose of this study is to explore the strategies used by Mathematics teachers to develop the concepts of probability in Grade 6 classes.

My study will involve teachers and learners in Grade 6 from Nkangala district. Each selected school will serve as a site for conducting the relevant research. All the data collected from each school will be analysed and a report regarding the study will be written.

The information from this study will only be used for academic purposes. In my research report, and in any other academic communication, pseudonyms will be used and no other identifying information will be given. Collected data will be in my or my supervisor's possession and will be locked up for safety and confidentiality purposes. After completion of the study, the material will be stored at the University's Science Mathematics and Technology Education Department, according to the policy requirements.
This research study is being carried out in the hope that it will contribute to the body of knowledge on how probability concept could be developed in Grade 6 classes.

Kindly be informed of the following conditions of participation in the research study.

1. All participation is voluntary.
2. The school's name will not be revealed in the findings of the research study.
3. All discussions with participants will be treated with confidentiality.
4. The schools can withdraw from the research study at any time.
5. If the school is willing to participate, it will kindly be requested to sign the consent form provided to it.

Signature of student

Name of student: (supervisor)

APPENDIX D_1: PERMISSION FROM THE DEPARTMENT OF EDUCATION

MPUMALANGA PROVINCIAL GOVERNMENT

ENQ: K.W. MASHIKE
CELL: 082 968 9126
266 MASOGANENG
FAX: 086 549 5045

P.O.BOX 75
LEFIFI
NOKANENG
0435

DEPARTMENT OF EDUCATION
NOKANENG CIRCUIT

To : Kodisang S.M
P.O.Box 21
Skilpadfontein
0431

From : Nokaneng Circuit Manager
Mashike K.W.

Date : 19 April 2013

Subject : **Approval to conduct Mathematics research.**

The circuit is appreciating your initiative of conducting a research in Mathematics in grade 6. Most of the learners are failing Mathematics in the senior phase and your research might assist in finding out the courses of high failure rate in the subject.

The circuit is therefore granting you permission to visit schools and do that research, and in turn you should present your findings for the circuit to improve.

The circuit wishes you all the best in the studies you wish to pursue.

Yours Faithfully,

Mashike K. W. (Circuit Manager)

DEPARTMENT OF EDUCATION
NOKANENG CIRCUIT OFFICE
CIRCUIT MANAGER
2013 -04- 19
NKANGALA REGIONAL OFFICE
MPUM... INCE

APPENDIX D_2: PERMISSION FROM THE DEPARTMENT OF EDUCATION

MPUMALANGA PROVINCIAL GOVERNMENT

Private Bag X 499
HAMMANSKRAAL
0400
South Africa

Tel (012) 721 2361/3
Fax (012) 721 2360

DEPARTMENT OF EDUCATION

NKANGALA REGIONAL OFFICE

MMAMETLHAKE CIRCUIT OFFICE

ENQ: M.H. TOMPA
TEL: 012 7212363/1

TO: THE CHAIRPERSON
RESEARCH ETHICS COMMITTEE
FACULTY OF EDUCATION
UNIVERSITY OF PRETORIA

FROM: M.H TOMPA
CIRCUIT MANAGER

DATE: 30/04/2013

SUBJECT: PERMISSION TO DO RESEARCH PROJECT

1. This matter bears reference.
2. Mrs. Sophy Mamanyena Kodisang, you are hereby permitted by the circuit manager, Mr. M.H TOMPA, to do your research project at the schools you will identify.
3. We wish you great success in your engagement with teachers, SMTs and learners.

.....
M.H TOMPA
CIRCUIT MANAGER

MDOE
MMAMETLHAKE CIRCUIT OFFICE
30 APR 2013
Private Bag X499
Hammanskraal 0400

APPENDIX D_3: PERMISSION FROM THE DEPARTMENT OF EDUCATION

MPUMALANGA DEPARTMENT OF EDUCATION

PRIVATE BAG X499
Hammanskraal
0400
TEL 012 7249947
FAX 012 7249952

NKANGALA DISTRICT OFFICE
MARAPYANE CIRCUIT
Litiko leTemfundvo Umyango wefundo Departement van Onderwys Umnyango wezeMfundo Lefapha la Thuto

FROM : THE CIRCUIT MANAGER
MARAPYANE CIRCUIT

TO : Ms S.M KODISANG
P.O.BOX 21
SKILPADFONTEIN
0431

Re: APPLICATION TO CONDUCT A RESEARCH STUDY IN THE CIRCUIT SCHOOLS

Your application to conduct an educational research study in the circuit schools has been received.

The research topic: "Teaching strategies used by mathematics teachers to teach Grade 6 probability in Nkangala District", is regarded as being very important. The ANA diagnostic report reflects poor performance by learners especially in Mathematics. It is for this reason that the circuit (department) will welcome measures that will assist in improving the performance of learners.

The circuit believes that the research study will be conducted without disrupting schooling as learners 'contact time cannot be compromised. We therefore request that you share with our schools the findings of your research as this will improve the quality of teaching and learning.

The circuit will like to wish you the best in your studies and that all concerned stakeholders will eventually benefit from this exercise.

Approved/~~Not Approved~~

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

CIRCUIT MANAGER

DEPARTMENT OF EDUCATION
MPUMALANGA PROVINCE
CIRCUIT MANAGER
2013 -04- 26
MARAPYANE CIRCUIT OFFICE
PRIVATE BAG X499 HAMMANSKRAAL 0400

2013/04/26
DATE

APPENDIX E: LETTER TO THE PRINCIPAL

The Principal of----------Primary School

---------- Circuit

Subject: Permission to conduct a Research Project in your school.

Dear Principal,

I hereby wish to apply for permission to conduct research in your school. I am currently enrolled for an M.Ed. (General) in Mathematics and Science Education with the University of Pretoria in South Africa. My research topic is: **Teaching strategies used by mathematics teachers to teach Grade 6 probability in Nkangala District**

The purpose of this study is to explore strategies employed by the teachers in developing the concepts of probability in Grade 6 classes and to determine the challenges that they might face when teaching this concept.

I will be a non-participative observer for two probability lessons that will be presented by each teacher. A semi-structured interview will be conducted with the participant after the second classroom observation at a time and place that is convenient to both the participants and the researcher. The lesson observation and the interview will both be audio recorded for a verbatim transcription.

The information obtained from the interviews and observations will be treated with the strictest confidentiality and will be used solely for research purposes. Pseudonyms will be used when making reference to the school and participants, whose participation is completely voluntary.

The participants will therefore be expected to sign the consent form provided to them.

Each selected school will serve as a site for conducting this research. All the data collected from each school will be analysed and a report regarding the study will be written.

This study is carried out under the Supervision of DR J. N Mwambakana at the University of Pretoria (Department of Science, Mathematics and Technology Education).

This research study is being carried out in the hope that it will contribute to the body of knowledge on how probability concept could be developed in Grade 6 class.

Yours Sincerely,

Signature of student

Name of student: (supervisor)

Contact number of student: 0824665968

E-mail address of student: **sophykodisang@yahoo.com**

CONSENT FORM FOR THE PRINCIPAL

I_____, principal at_____
_____school, give permission/ do

not give permission (strike off what is not applicable) for my school to take part in the research project titled: **Teaching strategies used by mathematics teachers to teach Grade 6 probability in Nkangala District**

I understand that lessons will be observed and thereafter interviews will be conducted. I have also been informed that these two activities will be audio taped.

By signing this letter of consent, I understand that participating in this research is voluntary. I understand that I will be fully informed about the research processes and developments at all times. I have been informed that my school's privacy with regard to confidentiality and anonymity will be protected at all times. I agree that my school may participate in this research provided that the information that is supplied by my school will be used for the purpose of enquiry only and that I will not be deceived in any way with regard to the aim of the research. The school will not be placed at risk by participating in this research. I also understand that there is no remuneration for participating and that the school will form part of the report regarding this research.

_____ _____

PRINCIPAL DATE

SCHOOL STAMP

APPENDIX F: LETTER TO THE TEACHER

To: Grade 6 Mathematics Teacher

----------Primary School

Dear Teacher,

I am a student currently enrolled for an M.Ed. (General) in Mathematics and Science Education with the University of Pretoria in South Africa. My research topic is: **Teaching strategies used by mathematics teachers to teach Grade 6 probability in Nkangala District**

The purpose of this study is to explore strategies employed by you (the teacher) in developing the concepts of probability in Grade 6 classes and to determine the challenges that you might face when teaching this concept.

I would like to be a non-participative observer for two of your consecutive probability lessons and, during this time, I will request your mathematics lesson plans for analysis purpose. I hope to then conduct a semi-structured interview with you after the second classroom observation at a time and place that is convenient to both of us. The lesson observation and the interview will both be audio recorded for a verbatim transcription.

The information obtained from the observation and interview will be treated with the strictest confidentiality and will be used solely for research purposes only. Pseudonyms will be used when making reference to the school and to you as the participant. Please note that your participation is voluntary and you are free to withdraw at any time during the study. You do not have to participate in this study if you do not want to and you will not be penalised should you decide not to participate. I assure you that the collected data will be in my possession or my supervisor's and will be locked up for safety and confidential purposes. After completion of the study, the material will be stored at the University's Science Mathematics and Technology Education Department according to the policy requirements.

If you agree to take part in this research, please fill in the consent form provided below. Feel free to contact the researcher or the supervisor at the numbers given below.

Yours Sincerely,

Signature of student

Name of student: (supervisor)

Contact number of student: 0824665968

E-mail address of student: **sophykodisang@yahoo.com**

CONSENT FORM FOR THE TEACHER

I, _____, employee at_____ school, give permission/ do not give permission (strike off what is not applicable) for my school to take part in the research project titled: **Teaching strategies used by mathematics teachers to teach Grade 6 probability in Nkangala District**.

I understand that the mathematics lesson plans will be analysed and classes will be observed for two consecutive lessons regarding this topic for the duration of a period, according to the teaching timetable. I understand and accept that the researcher will be a non-participative observer and that the lesson will be audio taped.

I understand that I will be interviewed about this topic for approximately 30-45 minutes at a venue and a time that will suit me.

By signing this letter of consent, I understand that participating in this research is voluntary. I understand that I will be fully informed about the research processes and developments at all times. My privacy with regard to confidentiality and anonymity will be protected at all times. I agree to participate in this study provided that the information that I am supplying will be used for the purpose of enquiry only and that I will not be deceived in any way with regard to the aim of the research. I acknowledge that I have been informed that I will not be placed at risk by participating in this research. I also understand that there is no remuneration for participating and that the information I give will only be used for academic purposes. I have been informed that a pseudonym will be used when referring to me in the research and in communication in order to ensure confidentiality and to protect my privacy.

_____ _____

TEACHER DATE

APPENDIX G_A: POST-LESSON INTERVIEW QUESTIONS AND RESPONSES OF TEACHER A

PART A: GENERAL QUESTIONS	
Question posed by the researcher	**Response**
How many years of experience do you have teaching Mathematics to Grade 6 learners	I have ten years' experience of teaching grade 6 learners mathematics
Rank the content areas to indicate the order of preference. The order should indicate your strength from good to not comfortable	The order of my preference is as follows: Numbers, Operations and relationships→Measurement→ Data Handling→Space and Shapes→Patterns, Functions and Algebra
Can you briefly tell us about the mathematics workshops that you attended?	The content- enrichment workshops are valuable in the sense that we share good practices that we can implement in our various schools, time-. The only challenge is that they are time consuming because we have to cover content within a short space of time. In most cases our content –enrichment workshops cover numbers, operations and relationships because learners are struggling with fractions and the content area forms the basis of other content areas. I have never attended a workshop on Probability.
Do you normally prepare a lesson before presenting it to learners and why?	Yes, to teach step-by-step as planned. To make sure that I do not miss any step. To use it as planned
What basic elements did you consider important in planning the lesson you presented?	Well, to me, classwork, homework, support activities and prior knowledge play a very important to make my lessons a success.
PART B: QUESTIONS RELATED TO TEACHING AND LEARNING	
What are your strengths and weaknesses (challenges) with regard to facilitating a lesson on Probability	Generally, my strengths are on explaining the terms/concepts and on doing practical activities. My weak points are on giving too many examples and demanding more answers from learners when teaching, and that consumes lot of time.
What necessary and appropriate resources do you use to effectively present your lesson?	I use textbooks to refer activities from, worksheets for learners to do class activities, dice and cards for practical activities.
What do you think usually prevents learners from achieving the intended outcomes. How, can you address this challenge?	The manner in which the lesson is presented. If you don't use resources when presenting your lesson ,because mathematics is abstract., I can address the challenge by using concrete objects and repeat the lesson if possible
To what extend do you consider	Most of the activities are applicable to the real-life situations.

the teaching of Probability important?	Like the weather forecast. For example, the Probability that tomorrow it will be cloudy is 60%. So, the understanding of these concepts is necessary for learners to use them appropriately in their real-life situation.
Which aspects do you consider essential in the teaching of Probability	Learners need to know the basic operations, because they are applicable in all the content areas of mathematics. Resources must be accessible and used appropriately. You know, I believe that the use of the dictionary is very important for learners to understand the meaning of a concept before they can use it. Learner involvement is also crucial for effective teaching in the classroom. Integrating Mathematics with other Subjects for learners to see the interrelatedness of the subjects
To what extend do you consider the use of different teaching strategies important.	From my experience as a teacher, I believe that learners learn in different ways, for example others learn best by listening and others learn best through practical activities.
What teaching strategy do you use to make your lesson very interesting?	Grouping learners is the strategy that works better for me because I make sure that all the learners participate and I allocate roles to each member of the group.
How do you check learners' understanding during the presentation of your lesson	I expect learners to explain the word Probability, perform activities and record the outcomes and give examples in real-life situation using the language of Probability.
Describe the level of emphasis that CAPS placed on Probability.	CAPS specified that for teaching and learning of Probability, the use of resources to do practical activities is very important. Resources like die, spinners and coins
PART C: REFLECTION ON THE LESSON PRESENTED	
What were the outcomes of your lesson?	My intention was for learners to be able to explain the concept Probability and also be able to give examples in real-life situations to describe Probability concepts.
Why did you choose to structure the lesson the way it was structured?	The structure is easy to follow and the activities are standardised.
How can you improve the teaching of Probability in your future lessons	I can improve by revisiting the strategies I used and do activities as specified in the CAPS document.
Thank you for your thoughts, time and effort in participating in this research study	Thank you too.

APPENDIX G_B: POST-LESSON INTERVIEW QUESTIONS AND RESPONSES OF TEACHER B

PART A: GENERAL QUESTIONS	
Question posed by the researcher	**Response**
How many years of experience do you have teaching Mathematics to Grade 6 learners	*I have 14 years' experience of teaching mathematics in Grade 6*
Rank the content areas to indicate the order of preference. The order should indicate your strength from good to not comfortable	*The order in which I like content areas is as follows: Data Handling→Numbers, Operations and Relationships→ Space and Shapes →Patterns, Functions and Algebra→ Measurement*
Can you briefly tell us about the mathematics workshops that you attended?	*We normally attend cluster workshops. In all the workshops that I have attended, including AMESA at branch level, Probability was not discussed.*
Do you normally prepare a lesson before presenting to learners and why?	*Yes, not to blunder in front of learners. Planning includes preparation of resources.*
What basic elements did you consider important in planning the lesson you presented?	*To me, the elements that I feel should form part of the lesson plan are as follows: Topic, problem solving strategy, resources to use, appropriate activities to check learners' understanding.*
PART B: QUESTIONS RELATED TO TEACHING AND LEARNING	
What are your strengths and weaknesses (challenges) with regard to facilitating a lesson on Probability	*I don't know my weaknesses. In most cases I make sure that I achieve my outcomes and I am good at integrating maths with other subjects.*
What necessary and appropriate resources do you use to effectively present your lesson?	*I use coins and worksheets*
What do you think usually prevents learners from achieving the intended outcomes. How, can you address this challenge?	*If preparation is not done properly. If the approach used in teaching is not learner centred. Learners learns best in small groups or in pairs*
To what extend do you consider the teaching of Probability important?	*I differentiate between facts and fiction and what is learnt in class is application to our everyday experiences.*
Which aspects do you consider essential in the teaching of Probability	*I consider knowledge of other subjects as importance to teach mathematics in the context of those subjects. Resources are important to make learning meaningful*
To what extend do you consider the use of different teaching strategies important.	*Different strategies will cater for different capabilities because the level of understanding for learners is not the same*

What teaching strategy do you use to make your lesson very interesting?	*I prefer to use the learner-centred approach because if learners do by themselves they will not forget and they learn best by making mistakes.*
How do you check learners' understanding during the presentation of your lesson	*I check their understanding through assessment activities like classwork, homework, including oral presentations by learners.*
Describe the level of emphasis that CAPS placed on Probability.	*CAPS encourage teachers to do experiments when teaching Probability.*
PART C: REFLECTION ON THE LESSONS PRESENTED	
What were the outcomes of your lesson?	*I wanted learners to master the language of Probability and be able to use it appropriately*
Why did you choose to structure the lesson the way it was structured?	*I preferred to give them a story to hook their interest in the lesson. I was also guided by the order of skills indicated in the CAPS document.*
How can you improve the teaching of Probability in your future lessons	*So far, I do not have any challenge. I would still present the lesson the same way.*
Thank you for your thoughts, time and effort in participating in this research study	*My pleasure*

APPENDIX G_C: POST-LESSON INTERVIEW QUESTIONS AND RESPONSES OF TEACHER C

PART A: GENERAL QUESTIONS	
Question posed by the researcher	**Response**
How many years of experience do you have teaching Mathematics to Grade 6 learners	*I have 9 years' experience of teaching mathematics in Grade 6*
Rank the content areas to indicate the order of preference. The order should indicate your strength from good to not comfortable	*If I had to rank the content areas according to where my strengths are, I would do it as follows: Numbers, Operations and Relationships → Measurement→Patterns, Functions and Algebra→Space and Shapes→Data Handling*
Do you normally prepare a lesson before presenting to learners?	*Yes, because it guides you on what to do. You make sure that you present as planned*
What basic elements did you consider in planning the lesson you presented?	*The following items should always form part of the lesson plan: topic, time, content, strategy for grouping learners and assessment*
Can you briefly tell us about the mathematics workshops that you attended?	*Most of the workshops we attended focussed on Numbers, operations and relationships as well as space and shapes. I have never attended a workshop on Probability.*
PART B: QUESTIONS RELATED TO TEACHING AND LEARNING	
What are your strengths and weaknesses(challenges) with regard to facilitating a lesson on Probability	*I am good at using resources, unpacking the concept. The challenge that I have is that some of the textbooks have scanty information*
What necessary and appropriate resources do you use to effectively present your lesson?	*I normally use coins and dice when doing experimental activities on Probability.*
What do you think usually prevents learners from achieving the intended outcomes. How, can you address this challenge?	*Eh ……, I think If you are not involving them. If there is shortage of resources. If the outcomes are not clearly defined.*
To what extend do you consider the teaching of Probability important?	*It assists learners in terms of predicting what could happen in future*
Which aspects do you consider essential in the teaching of Probability	*Understanding how to teach Probability and strategies or techniques to make sure that learners understand Probability*
To what extend do you consider the use of different teaching strategies important.	*They are important because learners learn in different ways.*
What teaching strategy do you use to make your lesson very interesting?	*In most cases I prefer to use resources and bright colours to make my lesson interesting*

How do you check learners' understanding during the presentation of your lesson	*I normally give them homework and classwork based on the presentation made.*
Describe the level of emphasis that CAPS placed on Probability.	*CAPS places emphasis on performing repeated events.*
PART C: REFLECTION ON LESSONS PRESENTED	
What were the outcomes of your lesson?	*I wanted my learners to perform experiments and record the outcomes of the experiments*
Why did you choose to structure the lesson the way it was structured?	*It shows all the stages of lesson development in a particular order.*
How can you improve the teaching of Probability in your future lessons	*Need to attend content-enrichment workshops on Probability*
Thank you for your thoughts, time and effort in participating in this research study	*Thank you too and hope to learn more from you about Probability*