AN INVESTIGATION OF GRADE 12 MATHEMATICS TEACHERS' COMPETENCIES IN THE TOPIC OF PROBABILITY

By

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Submitted in fulfilment of the requirements for the degree of

Master of Education

with specialisation in

Education in Mathematics

At the

School of Mathematics, Natural Sciences and Technology Education

Faculty of Education

University of the Free State

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JANUARY 2024

DECLARATION

I, Tshehlane Gladys Koma, hereby declare that this dissertation, *An Investigation of Grade 12 Mathematics Teachers' Competencies in the Topic probability,* I am submitting for the qualification of Master's degree at the University of the Free State, is my own independent work and that I have not previously submitted the same work for a qualification in any other institution of higher learning.

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January 2024

DEDICATION

I dedicate this dissertation to my dear husband, Morwankwana William Koma, and my two sons, Khutso and Kgaogelo Koma. I appreciate all their love, prayers, support, and sacrifices, allowing me to focus on this study.

I also dedicate this study to my parents, Makwateng and Manthe Thankge, and my siblings, Jimmy Thankge, Cylvia Thankge, Rebotile Malatjie and Julia Mafahla.

ACKNOWLEDGEMENTS

First and foremost, I would like to acknowledge the Almighty God for giving me the Grace, wisdom and strength to start and finish this study. Indeed, he has been good to me.

Secondly, I would like to acknowledge my supervisor, Professor Mogege Mosimege, for guiding me throughout the study until its completion. I wouldn't have done this without his constructive comments and leadership.

I would also like to acknowledge the five teachers from the MSTA schools in Mpumalanga for offering their time and willingly participating in my research.

Lastly, I wish to acknowledge my colleagues Dr MK Kekana, Ms AD Qhibi and Dr SN Dlamini for their encouragement and support during my studies.

ABSTRACT

The study investigated Grade 12 mathematics teachers' competencies in the topic of probability. Grade 12 learners are not performing well in probability in their National Senior Certificate (NSC) Examinations, affecting their overall mathematics performance. Mathematics has been the poorest-performing subject in the NSC Examinations compared to other gateway subjects. The Department of Basic Education (DBE) introduced the National Curriculum Statement (NCS) for Grades R to 12 in 2012. Probability is one of the topics introduced in 2012 in Grade 10. It was examined for the first time in Grade 12 in 2014. Since then, Grade 12 learners 'performance on the topic has not been satisfactory. Nationally, Grade 12s of 2022 performed at an average of 21 % in probability.

Teachers' competencies in mathematics teaching greatly influence learners' academic performance in mathematics. There are three domains of mathematical teacher competence that determine meaningful and effective teaching: teacher knowledge, skills, attitude and personality. The study followed a qualitative research method. The researcher conducted observations and semi-structured interviews with five Grade 12 teachers from Mathematics Science and Technology Focus (MSTA) schools in Mpumalanga.

The results indicate that in terms of teacher knowledge, teachers demonstrate sufficient mastery of content but lack pedagogical content knowledge in mathematics. More often, teachers did not specify the lesson aims at the start of the lesson. They mostly did not make clear, practical demonstrations. On the other hand, there was minimal demonstration of teacher skill competency by the teachers, and they seldom involved learners during the lesson. They focused more on delivering the subject matter and route learning. Teachers need to involve learners during the lesson to demonstrate teacher skill competency. Generally, learners were not encouraged to think critically, a crucial element in understanding probability.

Keywords: Mathematics teachers, Probability, teacher competencies

LIST OF ACRONYMS

CAPS	Curriculum and Assessment Policy Statements
DBE	Department of Basic Education
DCES	Deputy Chief Education Specialist
FET	Further Education and Training
MST	Mathematics, Science and Technology
MSTA	Mathematics Science and Technology Academy
NCS	National Curriculum Statement
NSC	National Senior certificate
PCK	Pedagogical Content Knowledge
RNCS	Revised National Curriculum Statement
TDS	Theory of didactical situations

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CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The National Curriculum Statement (NCS) for Grade R to Grade 12 was introduced by the Department of Basic Education (DBE) in 2012. The NCS builds on the previous curriculum, the Revised National Curriculum Statement (RNCS) Grades R-9 and the NCS Grades 10-12 (2002). The purpose of the NCS is to update the RNCS and clarify and describe what has to be learnt and taught in each of the four terms during the year.

The NCS Grades R to Grade 12, therefore, replaced the subject statements, Learning Programme Guidelines and subject Assessment Guidelines from the RNCS with the following:

a) Curriculum and Assessment Policy Statements (CAPS) for all approved subjects listed in this document;
b) National policy pertaining to the programme and promotion requirements of the NCS Grades R to 12; and
c) National Protocol for Assessment Grades R to12 (DBE, 2011).

Probability is one of the topics that was introduced in 2012 in Grade 10 according to Further Education and Training (FET) mathematics CAPS. It was examined for the first time in Grade 12 in 2014. Since then, Grade 12 learners have performed poorly on the topic. The average performance in probability has never been above 34%.

Teachers' competencies are vital in mathematics teaching; they highly influence how learners perform in mathematics. Boyatzis and Kolb (1995) state that competence refers to three aspects: knowledge, capabilities, and experience, which enable a person to carry out their duty impeccably. Blömeke et al. (2020) view teacher competence as an all-inclusive idea that covers a wide range of subject-specific and generic aspects of mathematics teachers' knowledge, skills, and beliefs. In this study, Grade 12 mathematics teachers' competencies in the topic probability were investigated to determine how they affect the learners' performance.

1.2 BACKGROUND TO THE RESEARCH PROBLEM

The Mpumalanga Education Department employs the researcher as a Deputy Chief Education Specialist (DCES) for FET Mathematics in its OR Tambo Mathematics Science and Technology Academy (MSTA). Her responsibility is to develop training materials and deliver in-service teacher training for the 101 Mathematics, Science and Technology (MST) focus schools in the province. Some of the researcher's responsibilities include analysing learner performance in June and Trial Examinations; the results inform in areas in which teachers need development. Item analysis on 2018 Trial Examinations revealed that many learners couldn't attempt the questions on probability. In 2019, the researcher trained teachers on the mathematics topic of probability to establish whether teachers had learned something. Pre- and post-tests were administered to measure the impact of the training. Forty-eight (48) teachers who attended the training performed at an average of 37% in the pre-test and 78% in the post-test. Moreover, in 2021, the researcher conducted training in Financial Mathematics. On their evaluation forms, 60% of the teachers indicated they needed probability training, which might be an indication that teachers are not competent enough in the topic of probability.

According to Mokkapati and Mada (2018), administering pre- and post-tests effectively measures how the workshop impacted teacher knowledge. They believe the same questions must be utilised for both pre and post-tests for the results to be meaningful. "Pre-test/post-test evaluation has been recommended as a good method of evaluation of a program, as it is concise and brings about a reasonable dialogue on improvement in learning which has occurred during the program" (Mokkapati & Mada, 2018). Table 1.1 presents the results of both pre and post-tests administered during a Grade 12 teacher workshop conducted on the topic of probability by the researcher in August 2021. The workshop aimed to train teachers on Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) in probability. It has been 12 years since the topic of probability was introduced in the FET band in school. However, some teachers still score as little as 16% on a Pre-test. 46% of the teachers who wrote the pre-test performed at 60% and above, and 94% achieved 60% and above in the post-test. The workshop was not conducted as part of the study; however, some of the participants in this research were among the teachers who attended the workshop. The average

performance of the teachers was 52,1% on the pre-test and 88,9% on the post- test, which indicates a variance of 36,8%.

Table 1.1: Teacher pre-test and post-test results

	Pre-Test		Post-Test		VARIANT
	25	Total %	25	Total %	
1	7	28	22	88	60
2	12	48	24	96	48
3	6	24	20	80	56
4	5	20	13	52	32
5	4	16	15	60	44
6	15	60	25	100	40
7	19	76	22	88	12
8	20	80	24	96	16
9	22	88	23	92	4
10	19	76	25	100	24
11	9	36	17	68	32
12	20	80	25	100	20
13	8	32	25	100	68
14	19	76	25	100	24
15	7	28	18	72	44
16	23	92	25	100	8
17	9	36	19	76	40
18	15	60	25	100	40
19	4	16	10	40	24
20	5	20	19	76	56
21	7	28	23	92	64
22	11	44	24	96	52
23	15	60	25	100	40
24	11	44	25	100	56
25	15	60	19	76	16
26	8	32	25	100	68
27	20	80	25	100	20
28	18	72	25	100	28
29	12	48	25	100	52
30	8	32	19	76	44
31	14	56	25	100	44
32	20	80	23	92	12
33	19	76	25	100	24
34	15	60	25	100	40
35	14	56	25	100	44
36	8	32	18	72	40
37	19	76	25	100	24
		52,1		**88,9**	**36,8**

For nine years, there has been evidence of perpetual underperformance in Probability by Grade 12 learners in their final examinations. According to DBE diagnostic reports, the average pass percentage of Grade 12 learners in probability in 2014 was 34% (DBE 2014). It has not improved over the years, as illustrated in Figure 1.1 below. In 2022, learners performed at an alarming average of 21% in the topic (DBE 2022).

Figures 1.1, 1.2 and Table 1.2 below, extracted from the 2022 NSC Diagnostic Report and the 2022 NCS Reports, indicate that mathematics is still the lowest-performing subject compared to all the other gateway subjects. On the other hand, probability continues to be one the most failed topics in Paper 1 in 2022, as evidenced by the graph average pass percentage in question 10; probability is 21%.

There are several contributing factors to how learners perform in mathematics. Several studies thus far have linked learners' performance to various factors. Factors such as gender, socio economic status, school environment, parental support, learners' problem-solving skills, learners' attitudes, teachers' methods of teaching and cultural differences have been explored by different researchers. According to Mbugua, Kibet, Muthaa and Nkonke (2012), socioeconomic status impacts learners' achievement in Mathematics.

Howie (2003) indicates that language is one of such contributory factors. According to Arends, Winnaar and Mosimege (2017), how teachers interact with learners and their classroom practices is highly important in comprehending mathematical ideas and overall performance in mathematics. Michael (2015) found that the teaching and learning methods and learners' cultural backgrounds greatly influence learners' performance in mathematics. His study also revealed that student performance largely depends on teachers' utilisation of various instructional approaches. Analysing Figures 1.1, 1.2 and Table 1.2 with others from previous years' diagnostic reports, one may argue that mathematics would be one of the well-performing subjects if teachers were competent.

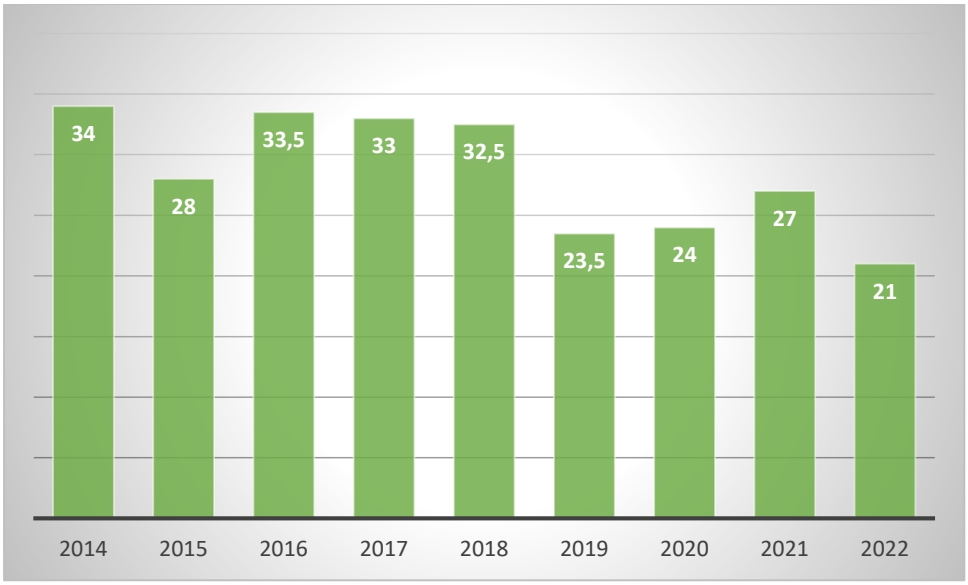
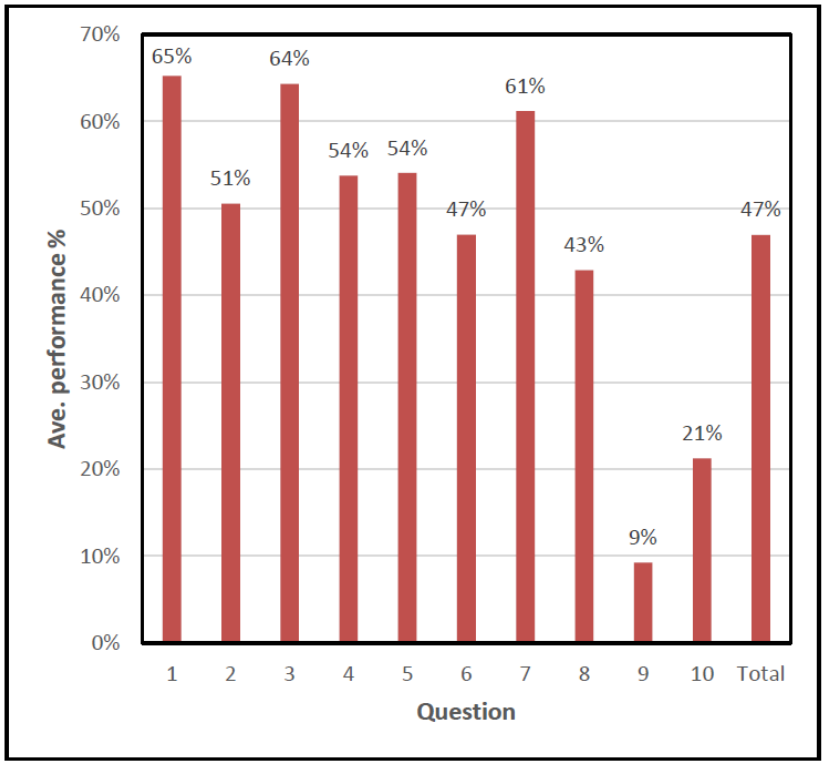


Figure 1.1: Average performance (%) in Probability from 2014 to 2022 (DBE diagnostic reports)



Q	Topics
1	Equations, Inequalities and Algebraic Manipulation
2	Number Patterns and Sequences
3	Number Patterns and Sequences
4	Functions and Graphs
5	Functions and Graphs
6	Functions and Graphs
7	Finance
8	Calculus
9	Calculus
10	Probability and Counting

Figure 1.2: Average performance per question in 2022 Mathematics paper 1 (DBE Diagnostic Report, 2022 p.198)

Table 1.2: Comparison of performance in gateway subjects at the 30 % level and above from 2019 to 2022

Subject Description	2019	2020	2021	2022
Accounting	78,4%	75,5%	74,7%	75,4%
Agricultural Sciences	74,6%	72,7%	75,4%	75,8%
Business Studies	71,0%	77,9%	80,5%	76,7%
Economics	69,3%	68,8%	67,9%	71,5%
Geography	80,5%	75,3%	74,3%	81,3%
History	90,0%	92,1%	89,5%	88,2%
Life Sciences	72,3%	71,0%	71,5%	71,5%
Mathematical Literacy	80,6%	80,8%	74,5%	85,7%
Mathematics	54,6%	53,8%	57,6%	55,0%
Physical Sciences	75,5%	65,8%	69,0%	74,6%

(Source: DBE NSC Exam Report, 2022, p.8)

According to Tshabalala and Ncube (2013), learners' poor performance in mathematics is attributed to teachers employing learning methods that do not enable learners to grasp mathematics concepts easily. They found that most teachers were incompetent enough to teach the subject effectively. They recommended improving the quality of mathematics teachers by utilising graduates who specialised in mathematics and regular in-service training for those currently teaching.

A study by Mwinuka and Tarmo (2021) revealed that learners taught by teachers with high scores on the Common Content Knowledge (CCK) domain had higher achievement than those taught by teachers with low scores. Since teachers are of great significance in teaching and learning mathematics, this study investigated the extent of their competencies in the subject, specifically probability.

1.3 PROBLEM STATEMENT

Grade 12 learners perform poorly in the topic probability in their final examinations, affecting their overall performance in their examinations in mathematics. Mathematics has been the lowest performed subject in the NSC Examinations compared to other gateway subjects. This trend has been observed since the inception of the NCS in Grade 12 in 2014. The perpetual underperformance of learners might, in probability, indicate that teachers are not competent enough in the topic in both knowledge and skills. Hence, this study investigated the probability competencies of Grade 12 mathematics teachers.

According to Vazalwar and Dey (2011), teacher competencies include knowledge, skill, and attitude, also called cognitive, affective, and psychomotor competencies. They argue that competencies are observable and demonstratable, making them measurable. They believe competency can be evaluated based on the teacher's performance. They indicate that teacher competencies may vary in knowledge, skill and attitude; other competencies may focus on skill or performance, whilst others comprise more knowledge than skill and attitude. Vazalwar and Dey (2011) further indicate that teacher competencies can be categorised as theoretical, circumstantial, content, transactional, educational tasks, assessment, management and competencies associated with community involvement and other organisations. They assert that various teaching competencies also cover knowledge of the topic, lesson planning, enthusiasm, demonstration and communication skills, evaluation and reflection and how one manages the classroom. All these competencies are imperative in teaching mathematics and probability.

1.4 RESEARCH QUESTIONS

1.4.1 Primary question

What are teacher competencies that affect learners' performance in the topic probability?

1.4.2 Secondary questions

1. Which teaching methods do teachers employ in teaching probability?
2. Which sub-topics of probability are teachers comfortable teaching?
3. How do the teachers teach the sub-topics they are uncomfortable teaching?
4. How do the teachers address the areas where the learners experience problems within probability?

1.5 AIM

Grade 12 learners perform very poorly on the topic of probability in their National Senior Certificate Examinations. Teachers play a very pivotal role in how learners perform in mathematics. This study purposed to investigate Grade 12 mathematics teachers' competencies in the topic of probability.

1.6 OBJECTIVES

- To identify the teaching methods teachers employ in teaching probability.
- To establish which sub-topics of probability teachers are comfortable teaching.
- To observe how teachers, teach the sub-topics they are not comfortable teaching.
- To explore how teachers, address the areas with which the learners experience problems in probability.

1.7 RESEARCH INSTRUMENTS

Semi-structured interviews and lesson observations were the two data collection methods employed for data collection in this research. A semi-structured interview schedule and a lesson observation sheet were used.

1.8 DATA COLLECTION PROCESSES

Five Grade 12 Mathematics teachers from five secondary schools in the Province of Mpumalanga were selected. The five secondary schools are five out of 101 Mathematics, Science and Technology focused schools in the province. These schools are offering only pure Mathematics and not Mathematical Literacy. The

researcher collected all the data (observations and interviews) at each school on the same day, spending one day at each school. A lesson in which the topic of probability was taught was observed, and then the teacher was interviewed thereafter. The sampling technique employed in this research is purposeful sampling. According to Palinkas et al. (2015), Purposeful sampling is a technique commonly used in qualitative research which involves recognizing and choosing participants that are well-informed about or skilled with the research topic.

1.9 DATA ANALYSIS

Data were analysed thematically using tables and graphs. As the teachers responded to interview questions, the researcher identified similar and related responses, which formed themes. Codes 1 to 5 were used to summarise the competencies of participants in a bar graph with 1- indicating Poor, 2- Unsatisfactory, 3- Satisfactory, 4- Exceeds Expectations and 5-Outstanding. Furthermore, a matrix table was used to represent areas in probability where learners are experiencing problems; these areas were represented with codes A, B and C on a table.

1.10 THEORETICAL FRAMEWORK

The theory which guided this study was the Theory of Didactical Situations (TDS). The theory focuses on the role played by the teacher and the learner in the learning environment. According to Brousseau (1997), in a teaching environment, a teacher is expected to stimulate the required adaptation in her students by giving them insightful and challenging types of problems. On the other hand, the problems must be thought-provoking to learners so that they become enthusiastic, work cooperatively, and develop and learn independently. TDS is relevant to the study as it clarifies the role of the teacher in a successful teaching and learning milieu. The purpose of this research was to investigate teacher competencies that are imperative in the learning of probability.

1.11 VALUE OF THE RESEARCH

This research investigated Grade 12 Mathematics teachers' competencies in probability. The study's findings will be valuable in the education sector; the education

department will be enlightened regarding knowledge levels and skills teachers hold in Probability. Through the results of this study, institutions of higher learning might see a need to develop courses that will capacitate teachers in probability. As a result of this research, scholars will gain a deeper understanding of probability, and educators will see why learners have underperformed.

1.12 OUTLINE OF CHAPTERS

This study consists of five chapters:

Chapter 1 introduces the study. It explains the study background, problem statement, research questions, and aim and objectives.

Chapter 2 offers a literature review and what previous scholars have found on the competencies of Mathematics teachers in the topic of probability. The chapter also deliberated on the theoretical framework that guided the research.

Chapter 3 discusses the methodology followed in the dissertation. It further explains the data collection method, research design and instruments, validity and ethical considerations.

Chapter 4 presents data collected from lesson observations and semi-structured interviews. Data is presented in excerpts, tables and graphs.

Chapter 5 discusses the key findings, shares limitations, and provides conclusions and recommendations for the study.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The chapter provides a review of the literature on Grade 12 Mathematics teachers' competencies in the topic of Probability. The literature reviewed focuses specifically on the following: Inclusion of the topic of Probability into the curriculum, how learners perform in Mathematics, learners' performance in Probability, PCK, teacher content knowledge of Probability, and teachers' conceptual understanding of probability. The TDS as a theory that guides the study is also discussed.

2.2 INCLUSION OF THE TOPIC OF PROBABILITY INTO THE CURRICULUM

In 2012, the DBE introduced the National Curriculum Statement (NCS) for Grades R to 12 (DBE, 2011). Probability is one of the topics that was introduced in 2012 in Grade 10, according to FET Mathematics Curriculum Assessment Policy Statements. It was examined for the first time in Grade 12 in 2014. Since then, Grade 12 learners have performed very poorly in the topic.

Teachers' mathematics teaching competencies are paramount in how learners achieve in mathematics. A study by Mwinuka and Tarmo (2021) revealed that learners taught by teachers with high scores on the CCK domain had higher achievement compared to those taught by teachers with low scores.

Jusoh, Salleh, Embong and Mamat (2018) indicate three domains of mathematical teacher competence that determine meaningful and effective teaching: teacher knowledge, skills, attitude and personality. They assert that teacher knowledge includes competency elements such as mathematical content knowledge and knowledge of mathematical content pedagogy. Teacher skills refer to, amongst others, classroom management skills, skills involving pupils, and communication skills. The teacher's attitude and personality speak of being motivated, believing in, patient, and curious.

2.3 LEARNERS' PERFORMANCE IN MATHEMATICS

A study by Ogbonnaya, Mji and Mohapi (2016) suggests that poor achievement of learners in Mathematics has been attributed to many factors, such as teacher knowledge, poor students' mathematics background, lack of teaching and learning resources, lack of parental involvement in students' learning, students' negative attitude towards mathematics, indiscipline among students, frequent changing of the curriculum, high student-teacher ratio and language barrier. Teacher knowledge is one of the competencies that this study was investigating.

A study by Michael (2015) found similar results to those of Ogbonnaya et al. (2016) that the teaching and learning methods and cultural backgrounds influence students' performance in mathematics. His study also revealed that student performance depends to a large extent on the teachers' use of different instructional strategies. For instance, involving students in problem-solving activities, self-practice, teachers demonstrating, and students contributing what they know about the topic under study in the teaching session. He further argues that the teacher-student relationship is vital in mathematics learning. He asserts that a good relationship motivates both teachers and students. Students tend to like the subject and develop a positive attitude towards their teacher. The learning environment becomes conducive (Michael, 2015).

Chand et al. (2021) state that underperformance in mathematics is a thorny issue for many countries worldwide. Their study investigated stakeholders' opinions concerning the causes of poor performance in mathematics at the senior grades of secondary schools in the districts of Ba and Tavua, Fiji. Their study targeted students, teachers, heads of departments, and school heads. They discovered students' negative attitude toward mathematics was one of the contributing factors towards underperformance in mathematics. Furthermore, it was established that an ineffective mathematics curriculum in secondary schools was another cause of poor performance in mathematics. They argue that mathematics teachers' quality, performance, and qualification are other imperative factors towards the attitude and achievement of students in mathematics. It was also revealed that many primary school teachers were not competent enough to teach mathematics at the primary school level. As a result, students' interest in mathematics diminished, leading to poor performance at upper and lower secondary levels. On the contrary, it was evident that secondary school teachers were relatively positive, of good quality, performing, and fully qualified in

teaching mathematics and delivering the subject matter. They recommended using technologies to teach mathematics, improving the quality of primary school mathematics teachers, reducing the emphasis on exams, and introducing internal assessments, projects, and fieldwork in the mathematics curriculum (Chand et al., 2021).

According to Arends et al. (2017), the role of teachers in delivering quality education is crucial. They argue that for learners to perform better in mathematics, it is imperative to look into how teachers use classroom instruction to involve learners and how they adjust their teaching and collaboration approaches. Their confidence in making learners aware of what is expected, their application of engagements in the classroom as a vehicle towards learning, and if their formative assessment is of value and how their feedback plans benefit the learning situation. It is then imperative to investigate the competency of teacher skills, which focuses on how the teacher manages classroom time and to what extent they involve the learners in their teaching. It is only when learners are actively involved that meaningful learning takes place.

2.4 LEARNERS' PERFORMANCE IN PROBABILITY

Probability is one of the fundamentals in the mathematics curriculum in the world across all levels of education, thus from primary to higher education. Research conducted by Tsakiridou and Vavyla (2015) has found that most learners in Grades 2-6 can compare probabilities of different events. They assert that Probability is a significant section of mathematics because it offers opportunities for learners to work with thought-provoking and purposeful learning activities. They further indicate that learners of various ages easily understand the topic, and it enhances mathematical thinking.

Sulfiah, Cholily and Subaidi (2021) view Probability as a challenging topic for learners, particularly in compound events. They said that learners usually experience difficulties in predicting events, which results in them having challenges in learning the topic of probability. They further indicate that learners find associating theoretical and empirical settings problematic.

According to Brase, Martinie and Castillo-Garsow (2014), what is most challenging to learners is the comprehension of probability concepts they should master and their

relatedness with other mathematical aspects. Mosimege (2012) states that enhancing meaningful teaching and creative learning in Mathematics, Science and Technology (MST) can be realised by identifying and establishing connections between mathematics and other subject areas. Mosimege (2012) further indicates that teaching and learning mathematics can also be enhanced by referring to suitable environments that can yield better mathematical understanding.

Based on the above argument, one can reason that the learners' performance will likely improve when classroom teaching is connected to real-life situations. In fundamental counting principles of Probability, learners are supposed to be taught the concept using very practical examples. Some of the real-life and practical examples that may be used as illustrations are:

1. The newly elected Learner Representative Council (RCL), Chairperson, secretary and treasurer must take a photo; how many ways can they be arranged?
2. You are going to visit your aunt. If you have two pairs of trousers, two shirts, and two pairs of shoes, how many different sets of clothes can you make?
3. As an owner of a company, you want to create identification codes for your employees. If the code must be made of two letters and four numbers, how many different codes can you make? Teachers must try to use such practical and real-life examples when teaching probability to enhance learners' understanding and improve their achievement.

Awuah (2018) established that learners are not doing well in the sub-topics of Probability, namely Tree diagrams, contingency tables, and fundamental counting principles, compared to other sub-topics of Probability taught in Grades 10 to 12 in South Africa. Awuah's research findings align with the NSC 2022 Diagnostic Report, which indicates that Grade 12 learners achieved 21% in question 10 on Probability and the fundamental counting principles (DBE,2023).

According to de Oliveira et al. (2018), Probability and statistics topics are of high importance in Higher Education institutions because there is a severe shortage of professionals qualified in this field that deals with an enormous amount of information that needs to be processed in the least possible interval and with an understanding of data analysis methods that support appropriate decisions resulting from interpretation

of sample data. Their study revealed that learners have a negative attitude towards probability and statistics because they are not doing well in these subjects. They argue that there is an indication that learners show little confidence in dealing with statistical and probabilistic problems; they do not feel confident about working on problems in the topics. Based on their findings, it may be deduced that the underperformance of learners in probability at the high school level affects their performance in the topic at institutions of higher learning.

In her research, de Kock (2015) found that teachers with more experience possessed more Mathematical content knowledge, which is consistent with the findings by Dana (2018).

2.4.1 Grade 12 learners' performance on the topic of Probability

Figure 2.1 indicates the Grade 12 learner performance in Probability from 2014 to 2022. It can be established from this graph that learners are struggling with Probability. Six years after the topic was examined in Grade 12, the learners still performed at an average of 23,5% in 2019.

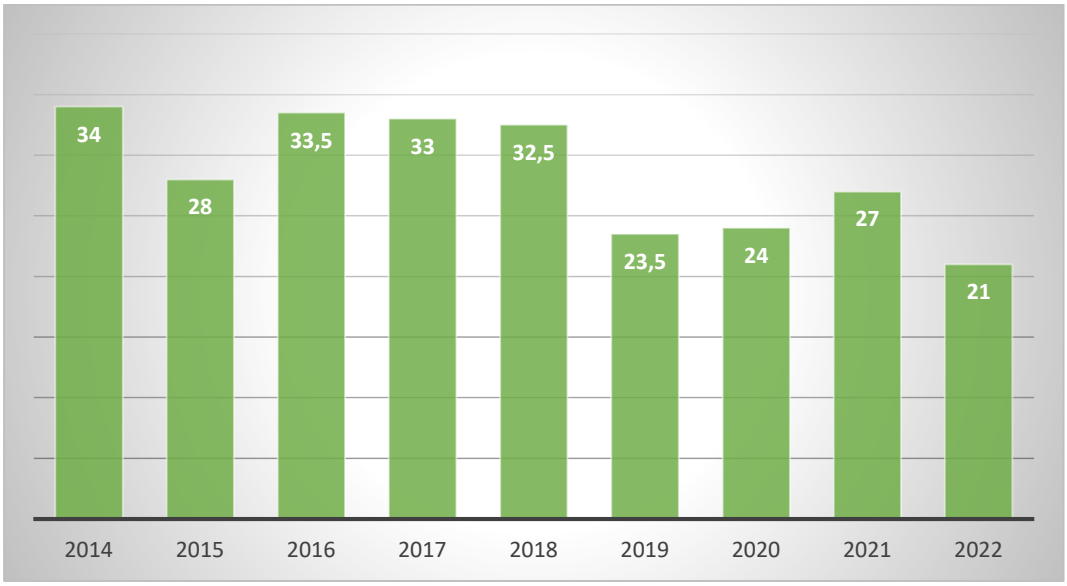
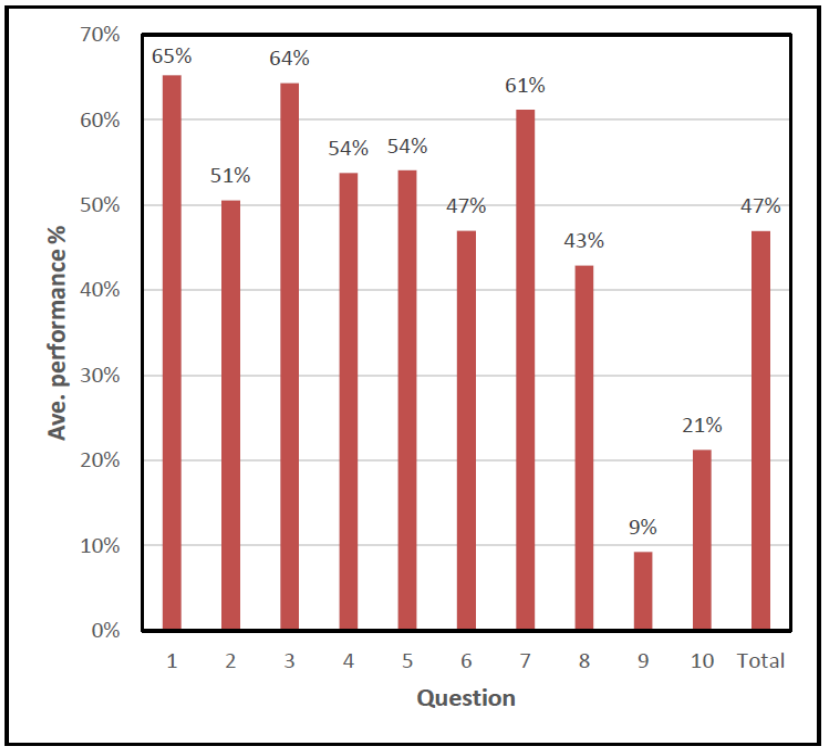


Figure 2.1: Average performance (%) in Probability from 2014 to 2022 (DBE diagnostic reports

The analysis of Grade 12 learners' performance per topic in their NSC 2022 Examinations indicates that they did not do well in Probability compared to the

previous years. In 2022, the learners 'average performance on the topic went down to an appalling 21% in Probability, as shown in Figure 2.2 below. Grade 12 learners are, without doubt, struggling in Probability; these figures might suggest that teachers are somehow not comfortable with the topic.



Q	Topics
1	Equations, Inequalities and Algebraic Manipulation
2	Number Patterns and Sequences
3	Number Patterns and Sequences
4	Functions and Graphs
5	Functions and Graphs
6	Functions and Graphs
7	Finance
8	Calculus
9	Calculus
10	Probability and Counting

Figure 2.2: Average performance per question in 2022 Mathematics paper 1 (DBE Diagnostic Report, 2022 p.198)

2.5 PEDAGOGICAL CONTENT KNOWLEDGE (PCK)

Hill, Rowan and Ball (2005) observed in their study that a noteworthy relationship exists between learner achievement in mathematical subjects and the mastery of mathematical content. They believe that pedagogy is also an integral component of teacher competency; thus, mathematics competency is not only in the knowledge of mathematics but also in the field of pedagogy. Shulman (1986) is of the view that PCK will help promote conceptual understanding. Teachers should pay more attention to their pedagogical content knowledge because it is essential to master how to teach the subject and not only the content. Mastering the PCK assist teachers in choosing and employing effective strategies and methods in creative teaching.

Jusoh et al. (2018) describe the competence of teachers as a combination of the domain of knowledge, skills, attitudes and personality of teachers in applying teaching practices that work effectively. They argue that teachers who mastered mathematical content have their learners' performance improved (Jusoh et al., 2018). They believe that three domains of mathematical teacher competence influence the practice of creative teaching: teacher knowledge, teacher skills, and teacher attitude and personality (Jusoh et al., 2018). They used Table 2.1 below, which the researcher finds instrumental in showing acceptable elements for each domain competence.

Table 2.1: Master's Domain and Element Competencies

Domain Competence	Competency Elements
Knowledge Teacher	a) Mathematical content knowledge b) Knowledge of mathematical content pedagogy; c) Knowledge of the students' ability level d) Knowledge of teaching resources e) Knowledge chooses teaching objectives
Skills Teacher	(a) Planning skills of preparation teaching (b) Classroom management skills (c) Skills to diversify teaching strategies (d) Skill involving pupils (e) Communication skills (f) Assessment of pupils' learning skills (g) Skills for teaching reflection (h) Skills to improve the level of professionalism
Attitude and Personality Teacher	(a) flexible (b) auctioneer (c) motivated (D) believe in (e) ready to take risks (F) patient (g) curiosity

(Source: Jusouh et al., 2018)

From Table 2.1, it is worth noting that teacher competency as a contributory factor to the learners' performance in Mathematics is not only about knowledge of the subjects but also includes the teacher's skills, attitude, and personality.

Teacher belief is a competency element under the teacher and personality domain, as outlined in table 2.1. “Teachers who believed that children learn mathematics by constructing their own understanding in the process of solving problems employ more word problems in instruction and spent more time developing children's counting strategies before teaching number facts than teachers who believed that mathematics is learned by receiving knowledge about mathematical operations from the teacher in discrete units (a more traditional view)” (Stipek, Givvin, Salmon & MacGyvers, 2001). A study by Peker and Ulu (2018) revealed that traditional beliefs do not have any bearing on anxiety about content knowledge, self-confidence, attitudes and pedagogical content knowledge. Their study further established that constructivist views influence the anxiety of math teachers toward mathematics teaching. On the contrary, Dana et al. (2018) have found that teacher beliefs instead of their experience are the most critical factors affecting teachers’ PCK. They argue that the teacher who possesses positive beliefs towards herself and the topic has good content knowledge and has the self-confidence to teach the topic more effectively to students. If a teacher is not confident enough to teach Probability, learners will likely become incompetent in the topic. Dana et al. (2018) further indicate that the more senior the teacher is, the more effectively they teach the topic of probability; they treat it like any other topic and not as a special one. That means the more experienced teachers are in the topic of probability, the more comfortable they are to teach it.

In his article “Towards a New Probability Curriculum for Secondary Schools,” Gage (2012) suggests a model that can assist teachers in teaching the topic of probability. He asserts that his mathematical modelling will assist teachers and learners in focusing on solving problems compared to merely calculating answers.

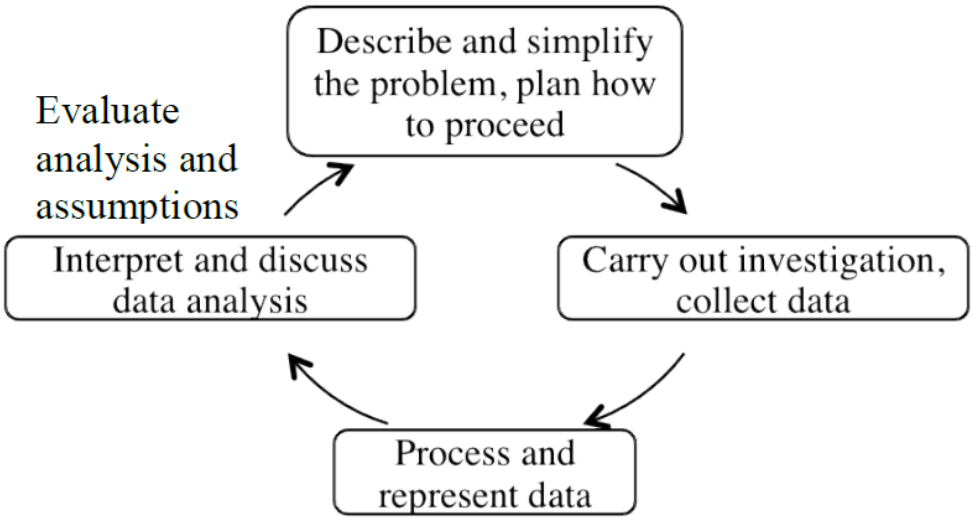


Figure 2.3: Gage 2012's Modelling Cycle

2.6 TEACHERS' UNDERSTANDING OF PROBABILITY

According to Gómez-Torres, Díaz and Contreras (2016), mathematical knowledge for teaching (MKT) is a type of knowledge teachers require to attain practical teaching objectives. There are three different categories of MKT, namely, Common Content Knowledge (CCK), Specialised Content Knowledge (SCK), and Advanced Content Knowledge (ACK). Thames, Sleep, Bass, and Ball (2008) define MKT as the mathematical knowledge required to accomplish the continuing tasks of teaching mathematics to learners. Unlike Gómez-Torres et al. (2016), they have identified four main domains of MKT namely: common content knowledge; specialized content knowledge; knowledge of content and students; and knowledge of content and teaching. Gómez-Torres et al.'s (2016) study revealed that soon-to-be primary teachers did not possess adequate knowledge of probability content. A significant number of teachers who participated in their study showed inadequate combinatorial thinking and committed mistakes in calculating conditional probability and in deducing frequent probabilities. In agreement with Gómez-Torres et al. (2016), Batanero, Contreras, Díaz and Sánchez (2015) found that calculating simple, compound, and conditional probabilities from a two-way table was challenging to teachers. Many teachers showed weak common knowledge of probability and could not answer correctly to the given sums.

> *"Probability is one unique area of science that helps us to quantify our information regarding unknown phenomena. Hence, it plays an important role in our daily life, where many situations are under uncertainty (e.g., tomorrow's weather, result of a medical surgery, graduation date). Because of such importance, Probability has been embedded within the mathematics curriculum from primary school level to teacher education"* (Elbehary, 2020).

Grade 12 Mathematics teachers in South Africa need to be competent in the following concepts of Probability, which learners are examined on in NSC Examinations:

- Mutually exclusive events and complementary events;
- The identity for any two events A and B: P (A or B) = P(A) + (B) - P (A and B);
- Dependent and independent events;
- Venn diagrams, contingency tables and Tree diagrams as aids to solving Probability problems (where events are not necessarily independent);
- A generalisation of the fundamental counting principle and
- Solving Probability problems using the fundamental counting principle. (DBE, 2011)

According to Batanero, Godino, and Roa (2004), Probability and statistics are part of the primary and secondary school mathematics curriculum. Still, most teachers are not well-trained in these sections of mathematics. Their study established that prospective secondary teachers who majored in Mathematics did not get specialised training in statistics education. They found that the situation is even worse with teachers in primary education who mostly do not have basic training in statistics. They are of the view that this situation is common to many countries. They argue that workbooks and syllabus brochures available for teachers offer insufficient support; they sometimes provide a minimal spectrum on probability where presentations are limited to games of chance, and in some instances, the concepts' definitions are incorrect.

Bahr and Bossé (2008) believe there should be a balance between theoretical and practical knowledge in teaching mathematics. They argue mathematics teaching generally has been characterised by focusing more on memorising processes, with little or no consideration of the linked concepts underlying them. According to Batanero, Henry, and Parzysz (2005), the uses of probability in diverse sciences were not popular, and to several secondary school teachers, Probability was a minor part

of mathematics; its focus was only on chance games. A study by Watson (2001) revealed that surveyed teachers did not possess specific expertise in probability and statistics.

They further indicate that computational methods that are over-practised without understanding are repeatedly forgotten or wrongly remembered. They believe that understanding without eloquence can impede the problem-solving process. Therefore, teachers teaching probability must be fluent and competent in the probability concepts so that they teach for understanding. However, in a study by Sulfiah, Cholily and Subaidi (2021), even though teachers are one of the factors influencing learning, their competencies in solving probability problems are still minimal.

2.7 THEORETICAL FRAMEWORK

The theory which guided this study was the theory of Didactical Situations (TDS). TDS focuses on the part played by the teacher and the learner in the learning environment. According to Brousseau (1997), teaching necessitates the teacher to incite the expected adaptation in her students by giving them a shrewd type of problem. The mentioned problems must be selected so the students can accept them; they must provoke them to be enthusiastic, interact, develop and learn independently.

The TDS perceives learning as a combination of two processes: learners' personal adaptation to a milieu (viewed through *a didactical* situation) and acculturation into an educational system (through didactical conditions and agreement) (Brousseau, 2000). There are two categories of actors in this situation, according to Brousseau (2000): the teacher, whose main aim is to teach some mathematical concept and the learners. The didactical contract connects these two actors.

Brousseau (1997) describes the didactic situation as a game characterised by a milieu, guidelines to relate with, a defined purpose to achieve, and how to become a winner. He further asserts that the teacher creates or selects this *milieu,* ensuring that the knowledge to be learnt is the knowledge to win, recognising that the prior knowledge of learners may assist them in emerging as winners in the game and gaining an understanding of the feedback of the *milieu*. According to Brousseau (1997), there exists three limitations on the *milieu,* namely*:* to incite paradoxes challenges for the learners, which aims at assisting them to acquire their own knowledge; to permit and

encourage them to work independently; and to aid them to acquire unknown definite mathematical content, learning to be winners in the game. This means that for them to learn, the learners have to play the game (participating themselves in collaboration with others), follow the rules (and not neglecting their own ideas) and look back into the whole thing considering the feedback of the milieu if they emerged a winner or a looser.

According to Nery (2022), the theory of Didactical Situations recognises the teachers' work to create suitable environments for the learners to build particular mathematical content, together with the content knowledge learners bring to class and their role in creating mathematical knowledge. The theory of Didactical Situations considers learners' prior knowledge as a valuable part of learning new content. In creating didactical situations that minimise learning obstacles, the teachers should plan lessons that match their character, that of learners and the classroom itself, maximising the learners' critical thinking (Sulistyowati et al., 2017).

According to the TDS, the teacher's role is to create an inquisitive environment for the learners, enabling them to create their own knowledge actively. Probability requires teachers to provide practical examples that will make learners understand the topic with ease. The teacher should start with practical examples before engaging learners in theoretical situations. The teacher must focus on easy examples before moving to more complex ones to allow learners to understand the concepts first, and then they can solve challenging problems in the topic on their own. "The concepts of TDS may help identify questions useful for the teacher in three moments: in the preparation of the class; during the lesson; in analysing what happened" (Mangiante-Orsola et al., 2018).

This study investigated Grade 12 teachers' competencies in the topic of Probability. The three competencies the study focused on were teacher knowledge, skills, attitude, and personality. TDS is the lens through which the researcher looked into each competency. It guided the researcher in unpacking and understanding what each competency means to a teacher in a classroom. The theory was found to be the most relevant to this study as its focus is on the role played by a teacher in a classroom in assisting learners in cooperating and creating their own knowledge, which is what the teacher competencies investigated in this study are all about.

For a teacher to be considered competent in the teacher knowledge skills, they must indicate mastery of both mathematical content knowledge and knowledge of mathematical content pedagogy and be able to make clear practical demonstrations, amongst other things. Regarding teacher skills competency, the teacher must involve learners during the lesson and develop activities that will allow learners to engage and build their own understanding and learning. On the other hand, Teacher attitude and personal skills refer to the ability of a teacher to demonstrate curiosity and encourage learners to think critically. The teaching of the topic of probability requires teachers to give learners practical examples, starting from well-known situations to complex ones. According to Nery (2022), TDS considers the teachers' work primarily to create appropriate milieus for the learners to build particular mathematical content, making the theory relevant to guide this study.

CHAPTER 3
RESEARCH METHODOLOGY AND RESEARCH DESIGN

3.1 INTRODUCTION

In this study, a qualitative approach was employed. This chapter gives details of the research methodology, research design, data collection and data analysis method. Lesson observation and semi-structured interviews as data collection instruments are discussed. This chapter also discusses ethical considerations, reliability, and validity issues.

3.2 RESEARCH METHODOLOGY

Quantitative, qualitative and mixed methods are three common approaches to conducting research. Creswell (2003) states that qualitative research is an all-inclusive methodology that comprises discovery. Qualitative research is also defined as a clarifying model in a natural environment that empowers the researcher to cultivate a level of detail from high involvement in real experiences (Creswell, 2003). One way of recognising qualitative research is when a social phenomenon is being researched from the viewpoint of a participant (Williams, 2007). Methodology is significant to the research process; it guides a researcher in decision-making on obtaining understanding and responses to the research questions. That means research methodology prescribes research designs and methods appropriate for a particular study (Ngulube, 2015).

3.3 RESEARCH APPROACH

The study followed a qualitative research method. Qualitative research methods are extremely important because they provide rich metaphors for complex phenomena (Sofaer,1999). Documents, observations, interviews and focus groups are data collection techniques commonly used in qualitative studies (Creswell *et al.,* 2007). According to Opdenakker (2006), concurrent communication in time and place identifies face-to-face interviews as one of four interview techniques in qualitative research. As a result, in-person interviews are advantageous because of social cues

such as voice, intonation, and the interviewee's body language. These social cues may provide the researcher with more valuable information that may be supplementary to the spoken answers provided by the participant to a given question. Interviews and observations were more appropriate for gathering this study's necessary information.

3.4 RESEARCH INSTRUMENTS

In this study, observations together with interviews were employed as ways and means for collecting data. A sample for this study includes five teachers from different Mathematics Science and Technology Academy (MSTA) schools in Mpumalanga. Five lesson observations and five interviews will be conducted. The same teachers were sampled for both observations and interviews.

3.4.1 Lesson Observation Guide

Lessons of all five participants were observed, one lesson per day, as the researcher visited the five schools on different days. Probability was the topic all participants taught on the day of observations. Lesson observations were conducted to discover methods of teaching used by teachers in teaching the topic, how teachers teach the sub-topics that they are not comfortable teaching, and how they address the areas where the learners experience problems within probability. The observer used a Lesson Observation Sheet (Annexure C) as a guide to gather information about the level of competencies of each of the five participants. The first page of the observation sheet has two columns, competencies and indicators, and the second page is a recording sheet where the observer wrote her notes about each teacher on each of the three competencies during the lesson. The three competencies that were observed are teacher knowledge, teacher skills, and teacher attitude and personality.

A teacher is considered competent in their knowledge skills and mastery of both mathematical content knowledge and knowledge of mathematical content pedagogy. The teacher must also be able to create clear, practical demonstrations when teaching. Regarding teacher skills competency, the teacher must value and prioritise learner involvement during the lesson, giving learners activities that will provoke them to think and work while creating their own understanding of the content and skills taught. Teacher attitude and personal skills competency is about how motivated the

teacher is, their patience and curiosity; competency indicators are confidence, curiosity and encouraging learners to think critically.

3.4.2 Interview Schedule

Semi-structured interviews were conducted with each participant on the same day as the lesson observations. The researcher used the Interview Schedule (Annexure B). The interviews aimed to collect data about the teaching methods they employ in teaching probability and sub-topics of probability they are comfortable teaching. The interviews further assisted in finding out how the teachers teach the sub-topics they are not comfortable teaching and how they address the areas where the learners experience problems.

3.5 RESEARCH DESIGN

An exploratory research design was followed in the study. According to Stebbins (2001), exploration is the act of examining an item or notion for investigative purposes to examine something analytically. According to Stebbins (2001), exploratory research demands extended hours of fieldwork of many forms and a particular personal interest in a topic researched, which will enable the researcher to withstand such examination. He further indicates that exploration can be executed for various reasons: discovery, which aims to be as broad and thorough as possible, or narrower and more focused innovation. He further explains that another form of exploration exists called limited exploration, whereby the researcher is interested in searching systematically for something in particular.

Stebbins (2001) believes that researchers explore when they do not possess scientific knowledge about their area of research; however, having valid reasons why they should investigate. To successfully examine a particular phenomenon, flexibility in searching for data and open-mindedness about places to find them are two distinct orientations researchers require.

The goal of exploratory research is to explore the problem; it is used to answer questions like what, why and how. Methods of collecting data for exploratory research include, among other things, surveys/polls, interviews, focus groups and observations.

Observations are done to observe a person and draw the findings from their reaction. On the other hand, interviews are conducted to gain in-depth information on an investigation. Interviews may be done in person or telephonically, and open-ended questions must be utilised to get meaningful information about the topic (QuestionPro, 2021).

3.6 DATA ANALYSIS

Thematic Analysis (TA) was considered appropriate to analyse data as this is a qualitative study. According to Guest et al. (2012), Applied Thematic Analysis (ATA) is a method of inductive analysis of qualitative data that includes several systematic procedures. It is an appropriate method for qualitative data analysis. The distinguishing feature of TA is that it surpasses just counting explicit words or phrases but focuses on identifying and describing both unspoken and clear ideas within the collected data, identifying themes (Guest et al.,2012),

TA aims to recognise themes, meaning significant patterns in the collected data. The themes are then used to unpack the research and make a statement about an issue. TA interprets data, reads between the lines and makes sense of it; It is not simply summarising it (Maguire & Delahunt, 2017). This study analysed data collected through lesson observations and Interviews through ATA.

The researcher identified several themes emerging from teachers' responses, and then data were analysed thematically using tables and graphs. After lesson observations, Codes 1 to 5 were used to summarise the competencies of participants in a bar graph, with 1 indicating Poor, 2- Unsatisfactory, 3- Satisfactory, 4- Exceeds Expectations, and 5- Outstanding. Interviews were conducted with each of the five participants; similar and related responses, which were forming themes, were identified by the researcher as the teachers responded to the interview questions identified by the researcher. Codes 1 to 5 were used to summarise the competencies of participants in a bar graph, with 1 indicating Poor, 2- Unsatisfactory, 3- Satisfactory, 4- Exceeds Expectations, and 5- Outstanding. A matrix table was used to represent areas in probability where learners are experiencing problems; these areas were represented with codes A, B and C on a table where A represents a Tree diagram, B represents Fundamental Counting Principles, and C represents None. Another table

was used to represent teaching methods employed by teachers in teaching the topic of Probability.

3.7 ETHICAL CONSIDERATIONS

The researcher applied for ethical clearance and was granted by the University (Annexure A). Furthermore, she was granted permission by the Mpumalanga Department of Education to conduct her research (Annexure E). Teachers who participated in the research did so voluntarily; they signed a consent form. Their information was kept anonymous using pseudonyms and codes in the research.

3.8 RELIABILITY

Reliability is another means of demonstrating the rigour of the research procedure and the trustworthiness of the study's findings (Taherdoost, 2016). According to Noble and Smith (2015), reliability is about the consistency and trustworthiness of the methods used in the research, that is, the ability of a researcher to maintain a decision trail. The researcher employed two methods to collect data in this study: lesson observations and semi-structured interviews. Through the thematic analysis of the collected data, the researcher ensured that the findings of this study were clear and transparent.

3.9 VALIDITY

Validity speaks of “the precision in which the findings accurately reflect the data” (Noble & Smith, 2015). For a study to be considered valid, it should exhibit what truly exists (Brink, 1993). Data was collected through semi-structured interviews and lesson observations and was thematically analysed by the researcher. The researcher ensured the validity of the research through openness to the participant; the notes captured by the researcher during interviews and observations were discussed with the participant.

CHAPTER 4
PRESENTATION OF RESEARCH FINDINGS

4.1 INTRODUCTION

The data collected from five different Mathematics and Science Focus (MSTA) schools in Mpumalanga were analysed for results. Data was collected through semi-structured interviews with five teachers from the five schools and lesson observations in those schools. Interviews and lesson observations were conducted to discover teacher competencies that are imperative in the teaching of the topic of probability; to identify the teaching methods teachers employ in teaching probability; to establish which sub-topics of probability teachers are comfortable teaching; to observe how teachers teach the sub-topics that they are not comfortable to teach and to explore how teachers address the areas that the learners experience problems within Probability.

Pseudonyms denote school names and participants to protect their identities: School 1- MI01, School 2- WC02, School 3 - MM03, School 4 - SS04 and School 5 - LMK05

The research findings will be outlined in this chapter in the following order:

- The background information of the five schools.
- The lesson observation findings of each teacher
- Interview excerpts with each teacher

4.2 THE BACKGROUND INFORMATION OF THE FIVE SCHOOLS

4.2.1 Background information of School 1

School 1 is a quintile 1 boarding school located in the rural farm area near a small town called Amsterdam in the Gert Sibande district. The Mpumalanga Education Department fully funds learners in this school. The school is regarded as a performing school in mathematics, with a 74.4 % pass rate in the 2021 NSC certificate examination. There were 51 learners in the class on the morning of data collection.

4.2.2 Background information of School 2

School 2 is a combined school in the Gert Sibande district just outside Carolina. It is a Quintile 2 school, a no-fee school considered poorer and allocated a higher subsidy by the government. Forty learners were present in class on the day of the observations. The school has obtained a pass rate of 55% in Mathematics in the 2022 NSC examinations.

4.2.3 Background information of School 3

School 3 is located in the deep rural area of the Nkangala district and is a Quintile 1 school. A Quintile 1 school is the poorest school according to the rankings of the DBE and receives the highest subsidy from the government compared to Quintile 2 to 5 schools. Learners in this school do not pay school fees. It is a small school, and it is classified as underperforming in mathematics. It has passed only 25.0% of the learners in Mathematics in the 2022 NSC examinations. Twenty-eight learners were present in class on the day of the observations.

4.2.4 Background information of School 4

School 4 is a secondary school in a well-known township near Middelburg called Mhluzi, making it a Quintile 3 school. A quintile three school is also considered poor but apportioned subsidy less than quintile 1 and 2 schools, which are the most impoverished. Fifty-four learners were present in class; the school has performed at a 50% pass rate in the 2022 NSC Examinations in Mathematics.

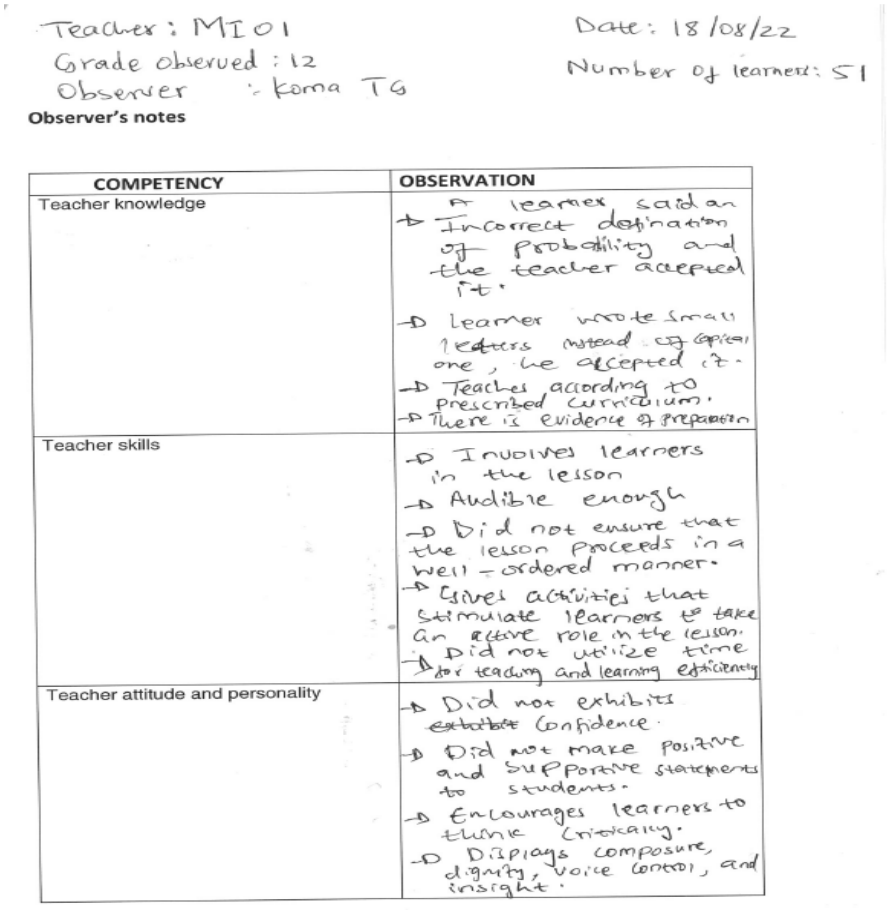
4.2.5 Background information of School 5

School 5 is a Quintile 1 school in the far north of the Bohlabela District, at the border of the Limpopo and Mpumalanga provinces. It is also considered the poorest and allocated the highest subsidy by the government, the same as school 3. The school is very close to the well-known tourist attraction of Mpumalanga, the Three Rondavels. However, it is the lowest performing of the five schools in mathematics; it has registered a performance of 26,3% pass rate in the 2022 NSC Examinations. Thirty-eight learners were in class on the day of the observations.

4.3 LESSON OBSERVATIONS

In this study, the five participants were Grade 12 Mathematics teachers from MSTA schools in Mpumalanga. The researcher visited one participant per day, and a Grade 12 mathematics lesson in which Probability was the topic taught was observed for each participant. The purpose of the lesson observations was to discover methods of teaching used by teachers in teaching the topic, how teachers teach the sub-topics that they are not comfortable teaching, how they address the areas where the learners experience problems within probability, and to observe the level of teacher competencies. The researcher used a Lesson Observation Sheet (Annexure C) as a guide and captured notes about each teacher on each of the three competencies during the lesson. The three competencies that were a focus of the lesson observation were teacher knowledge, teacher skills, and teacher attitude and personality.

4.3.1 Lesson Observation for Teacher MI01



Teacher : MI 01
Grade observed : 12
Observer : koma TG
Date : 18/08/22
Number of learners: 51

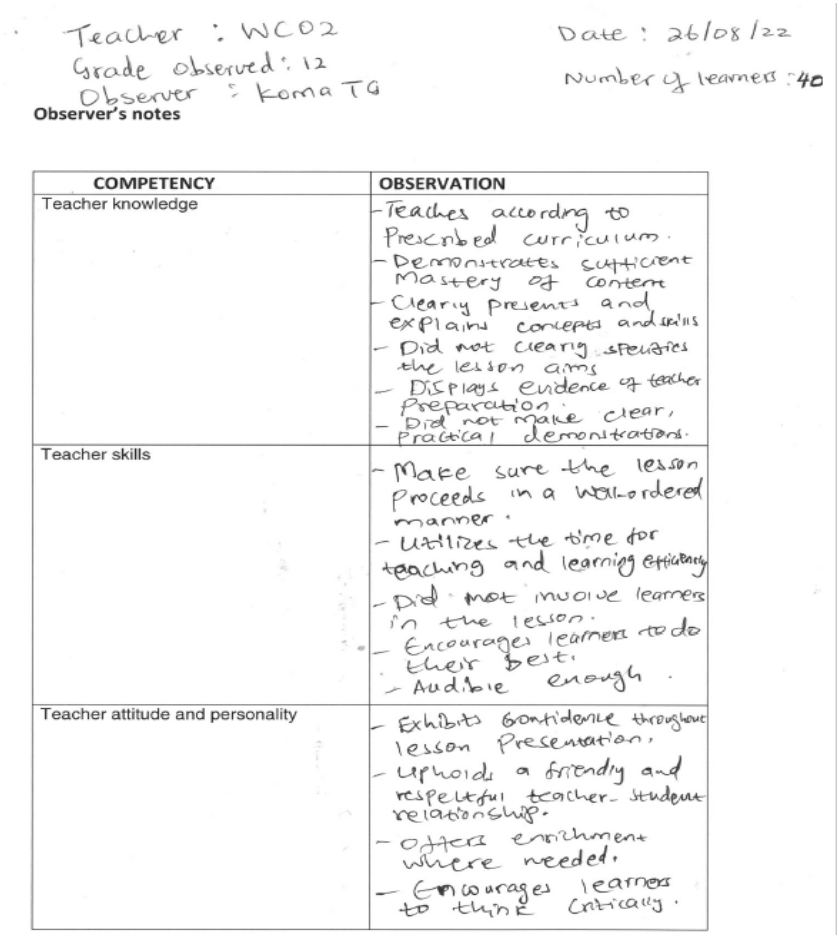
Observer's notes

COMPETENCY	OBSERVATION
Teacher knowledge	→ A learner said an incorrect definition of probability and the teacher accepted it. → Learner wrote small letters instead of capital one, he accepted it. → Teaches according to prescribed curriculum. → There is evidence of preparation
Teacher skills	→ Involves learners in the lesson → Audible enough → Did not ensure that the lesson proceeds in a well-ordered manner. → Gives activities that stimulate learners to take an active role in the lesson. → Did not utilize time for teaching and learning efficiency
Teacher attitude and personality	→ Did not exhibits confidence. → Did not make positive and supportive statements to students. → Encourages learners to think critically. → Displays composure, dignity, voice control, and insight.

Figure 4.1: Observation sheet for teacher MI01 's lesson

What was observed in terms of teacher knowledge is that he was not confident enough. During the lesson, learners made mistakes the teacher did not rectify but accepted as correct. At the beginning of the lesson, he asked the learners for a definition of probability; a learner raised her hand and gave an incorrect definition. To the researcher's surprise, the teacher said correct and continued the lesson. However, there was evidence that he had prepared for his lesson. He had prepared worksheets for the learners. He did involve learners throughout the lesson but somehow lost control of the lesson and did not ensure that it proceeded in an orderly manner. His voice projection was good; he was audible enough. Regarding teacher attitude and personality, MI01 was not confident enough, though he tried hard to encourage learners to think critically.

4.3.2 Lesson Observation for Teacher WC02



Teacher : WC02
Grade observed: 12
Observer : Koma TG
Date : 26/08/22
Number of learners : 40

Observer's notes

COMPETENCY	OBSERVATION
Teacher knowledge	- Teaches according to Prescribed curriculum. - Demonstrates sufficient Mastery of content - Clearly presents and explains concepts and skills - Did not clearly stipulates the lesson aims - Displays evidence of teacher preparation. - Did not make clear, Practical demonstrations.
Teacher skills	- Make sure the lesson proceeds in a well-ordered manner. - Utilizes the time for teaching and learning efficiently - Did not involve learners in the lesson. - Encourages learners to do their best. - Audible enough.
Teacher attitude and personality	- Exhibits confidence throughout lesson Presentation. - Upholds a friendly and respectful teacher-student relationship. - Offers enrichment where needed. - Encourages learners to think critically.

Figure 4.2: Observation sheet for teacher WC02 's lesson

WC02 demonstrated sufficient mastery of content, and her lesson aligned with the Annual Teaching Plan as prescribed in the CAPS document. However, she did not make clear practical demonstrations. Even though she did not involve learners in her lesson, she ensured the lesson proceeded in an orderly and efficient manner, utilising the time allocated. Studying her teacher skills, she focussed more on delivering the prepared content, not considering whether the learners could understand the content. Her attitude and personality were good; she continually fostered a good rapport with the learners and exhibited high confidence.

4.3.3 Lesson Observation for Teacher MM03

Teacher : MM03
Grade observed : 12
Observer : Koma TG
Date : 31/08/22
Number of learners : 28

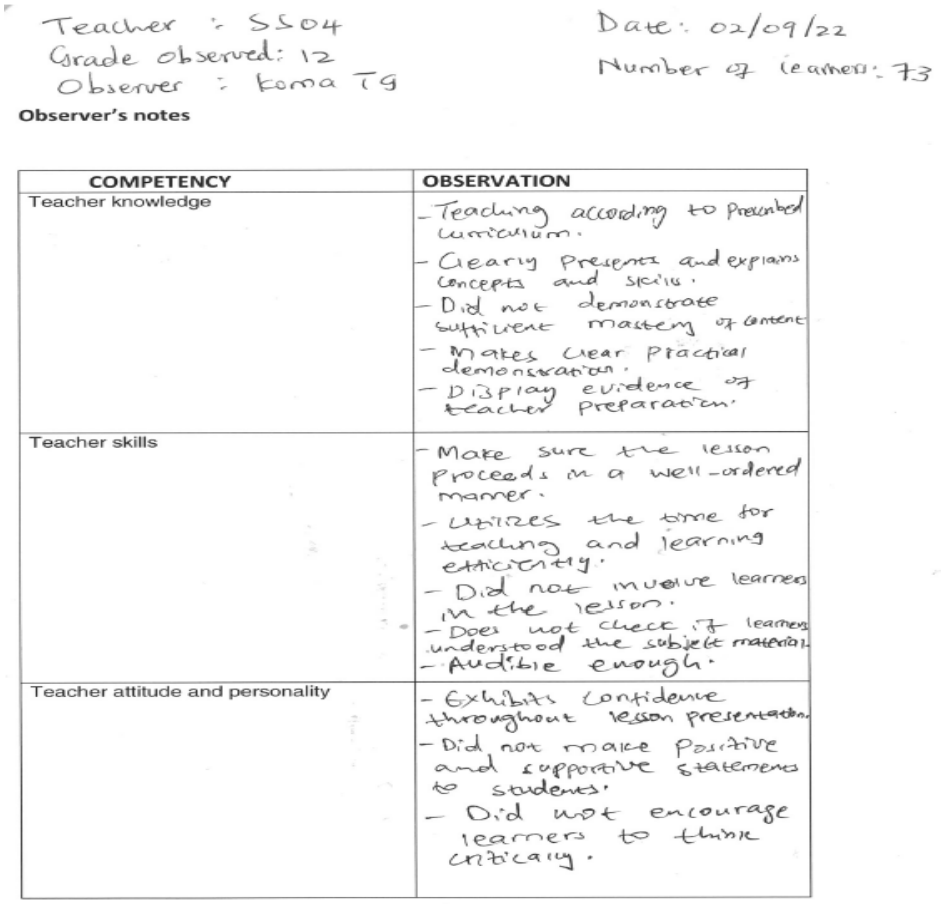
Observer's notes

COMPETENCY	OBSERVATION
Teacher knowledge	- Teaches in a well structured mode - linked new knowledge to pre knowledge very well - Teaches in a well - structured mode. - Makes clear, practical demonstrations. - Clearly presents and explains concepts and skills. - Demonstrates sufficient mastery of content.
Teacher skills	- Involves all learners in the lesson - Make sure the lesson proceeds in a well-ordered manner. - Utilizes the time for teaching and learning efficiently. - Gives clear instructions to learners - Audible enough. - Encourages learners to do their best
Teacher attitude and personality	- Exhibits confidence throughout lesson presentation - Makes positive supportive statements to students. - Upholds a friendly and respectful teacher-student relationship - Encourages learners to think critically.

Figure 4.3: Observation sheet for teacher MM03 's lesson

The observer was overwhelmed by what was obtained in the class that morning on the last day of August. The teacher was enthusiastic and seemed over-prepared for her lesson. Regarding the competency of teacher knowledge, MM03 demonstrated the highest level of mastery of content, and she clearly linked new knowledge to pre-knowledge. She invited three learners to the front and demonstrated the fundamental counting principle of probability; she used chairs to show different sitting arrangements. She involved learners throughout the lesson; her teaching skills were not questionable. She was audible and gave learners clear instructions. Regarding the teacher's attitude and personality, she was very confident throughout her lesson presentation, commented positively to learners, and encouraged them to think critically. Her lesson was lively.

4.3.4 Lesson Observation for Teacher SS04



Teacher : SS04
Grade observed: 12
Observer : Koma TG

Date: 02/09/22
Number of learners: 73

Observer's notes

COMPETENCY	OBSERVATION
Teacher knowledge	- Teaching according to Prescribed curriculum. - Clearly presents and explains concepts and skills. - Did not demonstrate sufficient mastery of content - Makes clear practical demonstration. - Display evidence of teacher preparation.
Teacher skills	- Make sure the lesson proceeds in a well-ordered manner. - Utilizes the time for teaching and learning efficiently. - Did not involve learners in the lesson. - Does not check if learners understood the subject material. - Audible enough.
Teacher attitude and personality	- Exhibits confidence throughout lesson presentation. - Did not make positive and supportive statements to students. - Did not encourage learners to think critically.

Figure 4.4: Observation sheet for teacher SS04 's lesson

SS04 had prepared for her lesson but did not demonstrate sufficient mastery of content knowledge. Probability requires practical demonstration to enhance the learners' understanding, which was not done at all. In terms of teacher skills, the teacher did well; she ensured that the lesson proceeded in a well-ordered manner; the only challenge is that she did not involve the learners or check if they understood the material. Regarding the teacher's personality and attitude, learners were not encouraged to think critically. She focused much on delivering the content. However, she was confident throughout the lesson.

4.3.5 Lesson Observation for Teacher LMK05

Teacher : LMK05
Grade observed: 12
Observer : Koma TG

Date: 24/10/22
Number of learners: 38

Observer's notes

COMPETENCY	OBSERVATION
Teacher knowledge	- Teaches according to Prescribed curriculum. - Did not demonstrate sufficient mastery of content. - Did not specify lesson aims. - There was evidence of teacher Preparation. - Did not make clear Practical demonstrations.
Teacher skills	- Did not involve learners in the lesson. - Did not check whether learners understood the subject material. - He was audible enough - Did not give learners any instructions. - Did not ensure that the lesson proceed in a well-ordered manner.
Teacher attitude and personality	- The teacher was confident throughout the lesson. - Did not make any positive and supportive statements to students. - Did not uphold a friendly teacher – student relationship - Did not encourage learner to think critically.

Figure 4.5: Observation sheet for teacher LMK05 's lesson

Even though LMK05 was taught according to the prescribed curriculum, the teacher's knowledge of probability was minimal. He did not specify the aims of the lesson; his mastery of the content was minimal. LMK05 never made any practical demonstration. He did not involve the learners or check if they understood his teaching. Regarding the teacher's attitude and personality, he was very audible but did encourage learners to think critically. For most of his lesson, learners watched the teacher write on the board and talk.

The following codes have been used to summarise the competencies of participants in the graph below. 1 indicates Poor, 2- Unsatisfactory, 3- Satisfactory, 4- Exceeds Expectations, and 5- Outstanding. On the bar graph, different colours denote particular competencies; blue represents teacher knowledge, orange represents teacher skills, and grey represents teacher attitude and personality. The participants are represented by pseudonyms on the graph: MI01, WC02, MM03, SS04 and LMK05.

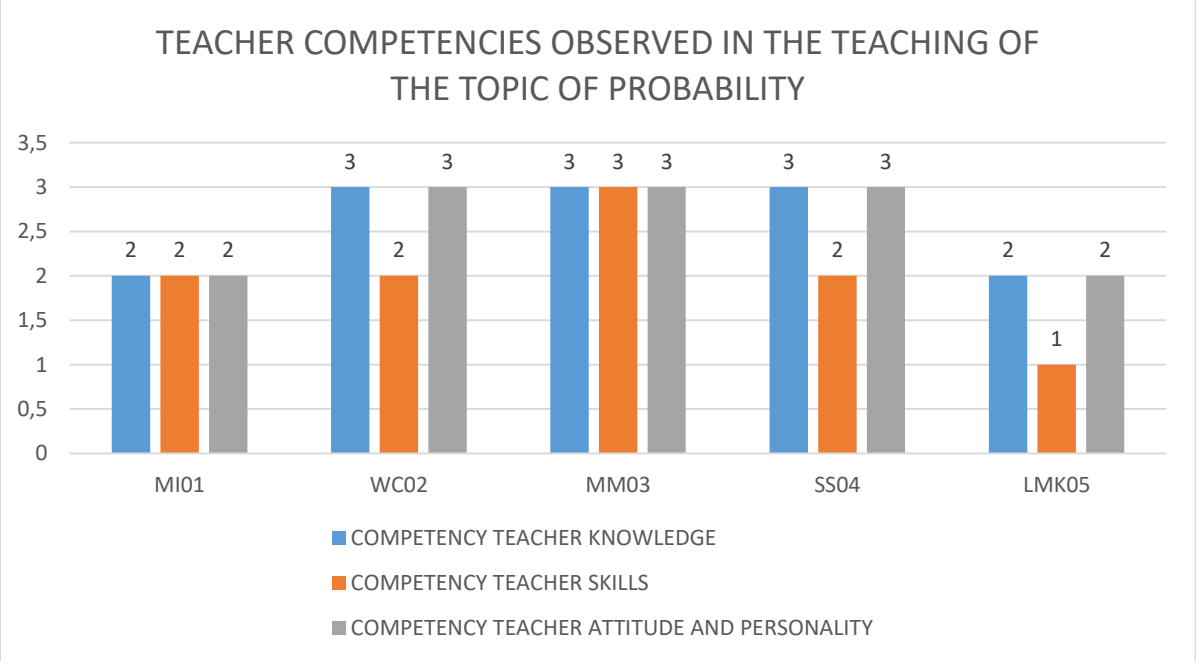


Figure 4.6: Graphical representation of teacher's competencies

As shown in Figure 4.6 above, teachers lack more in the teacher skills competency than the other two competencies. For a teacher to be regarded in the teacher competency skills, they need to involve learners and give activities that stimulate

learners to take an active role in the lesson, which was very minimal in the lessons observed.

4.4 SEMI-STRUCTURED INTERVIEWS

After lesson observation with each of the five teachers, semi-structured Interviews were conducted. The researcher followed the Interview Schedule (Annexure B) when interviewing the participants. The interviews aimed to collect data about the teaching methods they employ in teaching probability and sub-topics of probability they are comfortable teaching. Furthermore, interviews further assisted in establishing how the teachers teach the sub-topics they are not comfortable teaching and how they address the areas where the learners experience problems within probability. The following are interview excerpts of an interview with each participant. In these interview excerpts, the researcher will be referred to as TG, while the participants will be represented by pseudonyms.

Excerpt 1:

TG: *"What teaching methods do you use in teaching Mathematics?"*

MI01: *"Learner-centred method, Team-teaching method, peer teaching method and demonstration."*

TG: *"Which of the teaching methods you mentioned are more appropriate for teaching probability?"*

MI01: *"For probability, learners understand when we demonstrate or do it practically so."*

TG: *"Mention the sub-topics in probability that you remember. Please elaborate on skills and concepts taught in these sub-topics."*

MI01: *"Venn diagram, tree diagrams, contingency table and fundamental counting principles."*

TG: *"From the sub-topics that you mentioned, which ones are you comfortable to teach?"*

MI01: *"Venn diagram, contingency table and fundamental counting principles."*

TG: *"How do you teach the sub-topics that you are not comfortable with in probability?"*

MI01: *"We use team teaching. If I am not comfortable to teach the topic, I ask my HOD to assist me and the specialist, Mrs Koma, to come and assist me."*

TG: *"Are there areas in probability that learners experience problems?"*

MI01: *"Yes, in word problems that involve Tree diagrams."*

TG: *"How do you address areas that learners experience problems within probability?"*

MI01: *"I outsource for more clarity to the learners. "*

TG: *"Is there any other thing that you want to tell me regarding the teaching of probability? "*

MI01: *"For me I think workshops assisted me a lot because now I am confident in probability, but still I need more workshops."*

From the semi-structured interview with teacher MI01, the researcher has gathered that MI01 uses the learner-centred method, team-teaching method, Peer Teaching method and demonstration, and he believes that the demonstration method is the most appropriate for teaching probability. MI01's learners are finding problems with Tree diagrams. He asks teachers from other schools to tackle the topic. He asserts that teacher workshops conducted by the Mathematics specialist at the MST Academy (MSTA) are helpful to him.

Excerpt 2:

TG: *"What teaching methods do you use in teaching Mathematics?"*

WC02: *"Learner-centred approach, peer teaching and direct teaching (facilitating)."*

TG: *"Which of the teaching methods you mentioned are more appropriate for teaching probability?"*

WC02: *"Learner-centred approach and peer teaching."*

TG: *"Mention the sub-topics in probability that you remember. Please elaborate on skills and concepts taught in these sub-topics.*

WC02: *"Mutually exclusive events, complementary events, Independent events, Exhaustive events, counting principle, Venn diagrams and Tree diagrams."*

TG: *"From the sub-topics that you mentioned, which ones are you comfortable to teach?"*

WC02: *"Counting principle, mutually exclusive events, independent events, Venn diagrams and complementary events."*

TG: *"How do you teach the sub-topics that you are not comfortable with in probability?"*

WC02: *"Fortunate enough, the school hire a teacher from a teacher from other schools to assist, or even colleagues that are teaching mathematics also assist."*

TG: *"Are there areas in probability that learners experience problems?"*

WC02: *"Yes, in Tree diagrams, mostly the one that not replacing an object back."*

TG: *"How do you address areas that learners experience problems within probability?"*

WC02: *"We drill those challenges through extra classes, group work and through learner profiling. Weekly tests also assist a lot."*

TG: *"Is there any other thing that you want to tell me regarding the teaching of probability?"*

WC02: *"Probability is all about possibilities, our classroom motto. Therefore, for every learner, it is possible that he or she can pass maths, only if they practice and put so much effort in doing it."*

WC02 believes the learner-centred approach and Peer Teaching are the methods appropriate for teaching the topic of probability. She is comfortable teaching fundamental counting principles, mutually exclusive events, independent events, Venn diagrams and complementary events. She uses extra classes, group work and weekly tests to areas where learners are experiencing challenges.

Excerpt 3:

TG: *"What teaching methods do you use in teaching Mathematics?"*

MM03: *"Narrative, questioning and answer and demonstration."*

TG: *"Which of the teaching methods you mentioned are more appropriate for teaching probability?"*

MM03: *"Narrative and demonstration."*

TG: *"Mention the sub-topics in probability that you remember. Please elaborate on skills and concepts taught in these sub-topics."*

MM03: *"Fundamental counting principle and contingency table. Skills I remember is arrangement of words in different ways, number of choices in a position, repetition of letters and no repetition."*

TG: *"From the sub-topics that you mentioned, which ones are you comfortable to teach?"*

MM03: *"Fundamental counting principle."*

TG: *"How do you teach the sub-topics that you are not comfortable with in probability?"*

MM03: *"For now, I am comfortable with every topic, but if there is a topic I am not comfortable I ask other teachers to present that topic to my learners."*

TG: *"Are there areas in probability that learners experience problems?"*

MM03: *"None because I have gained a lot at the workshop, so learners understand everything on probability now."*

TG: *"How do you address areas that learners experience problems within probability?"*

MM03: *"I make extra classes so that I can explain to the learner again."*

TG: *"Is there any other thing that you want to tell me regarding the teaching of probability?"*

MM03: *"Teaching probability is very interesting and enjoyable."*

Teacher MM03 uses three methods in her Mathematics teaching: narrative, questioning, answer, and demonstration. She trusts that of the three methods, narrative and demonstration, are more appropriate for teaching probability. She is comfortable teaching all sub-topics in probability and finds the topic intriguing and fun.

Excerpt 4:

TG: *"What teaching methods do you use in teaching Mathematics?*

SS04: *"I use the synthesis method by asking learners questions and trying to get answers from which the explanation of the problem is done."*

TG: *"Which of the teaching methods you mentioned are more appropriate for teaching probability?"*

SS04: *"In probability, we have to explain the methods for learners to understand the concepts. Then learners can practice to figure out the different ways of answering questions."*

TG: *"Mention the sub-topics in probability that you remember. Please elaborate on skills and concepts taught in these sub-topics."*

SS04: *"Different types of events, independent events, Venn diagrams, Tree diagrams, contingency tables and the fundamental counting principles."*

TG: *"From the sub-topics that you mentioned, which ones are you comfortable to teach?"*

SS04: *"I am comfortable with teaching all topics."*

TG: *"How do you teach the sub-topics that you are not comfortable with in probability?"*

SS04: *"As I have indicated I am comfortable with teaching all topics."*

TG: *"Are there areas in probability that learners experience problems?"*

SS04: *"Learners experience problems in drawing Tree diagrams in some situations and counting principles."*

TG: *"How do you address areas that learners experience problems within probability?"*

SS04: *"Giving remedial lessons in extra time on afternoons and weekends."*

TG: *"Is there any other thing that you want to tell me regarding the teaching of probability?"*

SS04: *"If we get enough time to teach probability in detail, learners can score good marks on the topic."*

SS04 uses the synthesis method to teach Mathematics and says it is an appropriate method to introduce the topic of probability. She is comfortable teaching all sub-topics in probability. However, her learners experience problems in drawing Tree diagrams. She gives remedial lessons to address the learners' challenges. She indicated that if more time were allocated to teach the topic of probability, learners would do well.

Excerpt 5:

TG: *"What teaching methods do you use in teaching Mathematics?*"

LMK05: *"Questioning and answering, learner-centred method."*

TG: *"Which of the teaching methods you mentioned are more appropriate for teaching probability?"*

LMK05: *"Learner-centred teaching is going to be the best when they talk to each other and come up with formulae to solve problems*

TG: *"Mention the sub-topics in probability that you remember. Please elaborate on skills and concepts taught in these sub-topics."*

LMK05: *"Contingency tables are a method of finding probability for dependent and independent events; the table help them to see outcomes. Another one is the Tree diagram, it helps learners to see all possible outcomes. That is same as use of sets and Venn diagram and the fundamental counting principles."*

TG: *"From the sub-topics that you mentioned, which ones are you comfortable to teach?"*

LMK05: *"It's like all of them are interesting to me; I like all of them."*

TG: *"Since how do you teach the sub-topics that you are not comfortable with in probability?"*

LMK05: *"I use videos and animations."*

TG: *"Are there areas in probability that learners experience problems?"*

LMK05: *"Learners struggles with the high order of the fundamental counting principles."*

TG: *"How do you address this fundamental counting principle which learners are experiencing problems with."*

LMK05: *"Grouping them and asking one of them to present."*

TG: *"Is there any other thing that you want to tell me regarding the teaching of probability?"*

LMK05: *"Probability, people are living with it. For example, in research, it used to check the validity of the research. People use dice cards not being aware it is probability, even gambling. Even lotto, it is permutations or all games."*

Teacher LMK05 uses questioning, answering, and learner-centred methods in his mathematics teaching. According to him, the learner-centred method is the best in the teaching of the topic of probability. His learners are experiencing challenges with the sub-topic fundamental counting principles of probability. He divides them into groups and asks each group to present solutions to the class, encouraging them to take responsibility for addressing their challenges and assisting each other.

Table 4.1 summarises the interview findings in response to the question.

Table 4.1: Summary of mathematics teaching methods used by participants

TEACHER	METHODS
LMK05	Learner centred Questioning and answering
MI01	Learner centred Team teaching Peer teaching Demonstration
WC02	Learner centred Peer teaching Direct teaching
MM03	Narrative Questioning and Answering Demonstration
SS04	Questioning and Answering

It was further established from the interviews that two participants are comfortable teaching all topics in probability. On the other hand, three participants indicated they are comfortable with the fundamental probability counting principle, taught only in Grade 12. Two of the three participants are comfortable teaching Venn diagrams, the topic taught in Grades 10 and 11. Only one participant indicated he is comfortable teaching contingency tables and mutually exclusive and complementary events. Even though two participants indicated that they were comfortable teaching all sub-topics of probability, none specifically mentioned that they were comfortable teaching a sub-topic of Tree diagrams. It was noted by the researcher that when asked to mention areas of probability in which learners experience problems with said Tree diagrams, three of the participants mentioned that learners experience problems with Tree diagrams. Figure 4.7 summarises the findings from the interview excerpts about the sub-topics of probability teachers are comfortable teaching, which is one of the secondary research questions.

What was found to be common from the interviews and the observations is that teachers were indeed found to be confident in teaching the sub-topic of the fundamental counting principle of probability. All five participants were teaching this topic on the day of the observations. It is the only sub-topic of probability that is taught

in Grade 12; all the others are taught in Grade 10 and 11 but revised in Grade 12 since they are also examinable.

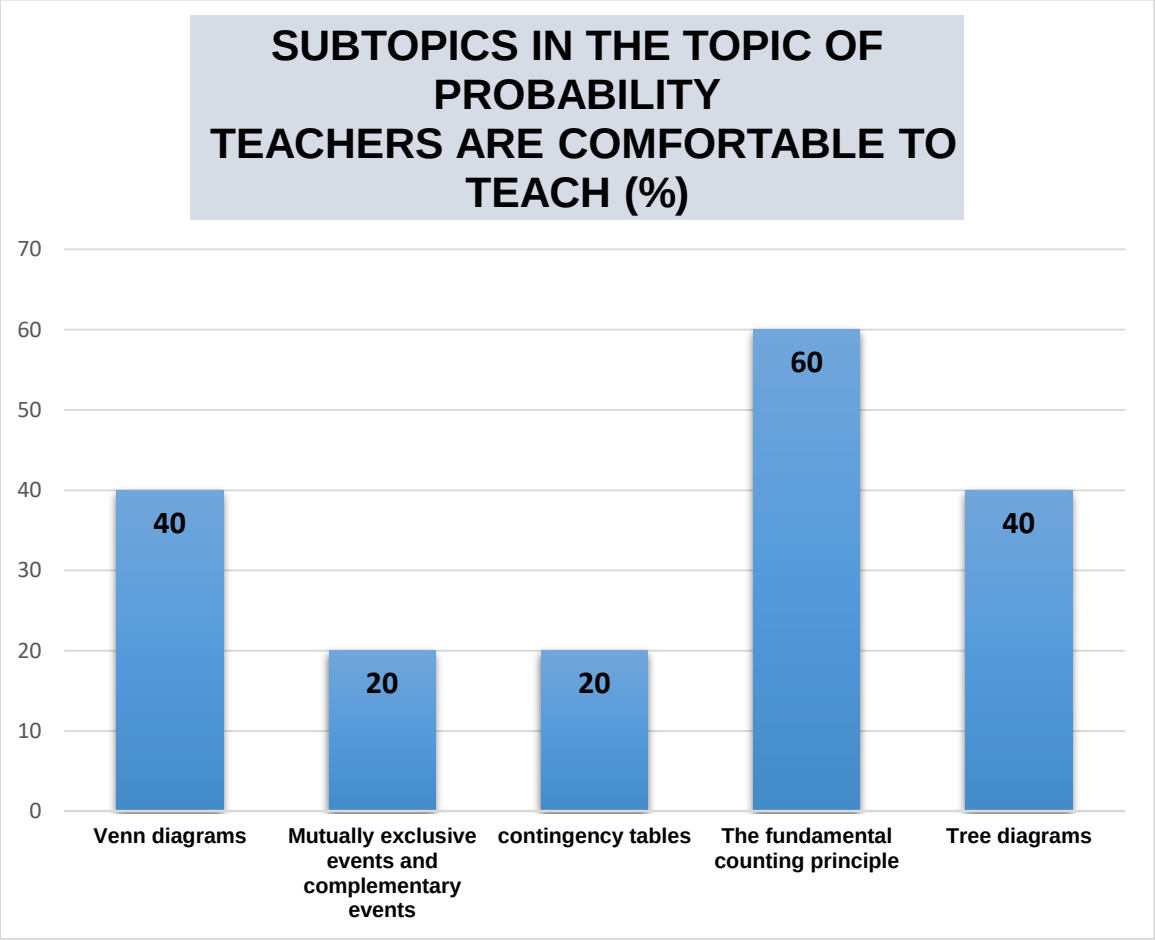


Figure 4.7: Graphical representation of sub-topics teachers are comfortable to teach

Thematic analysis interprets data, reads between the lines, and makes sense of it (Maguire & Delahunt, 2017). In interacting with the teachers through the interviews, the researcher recognised themes that emanated from their responses to a question on areas where learners experience problems in probability that learners. The similarity and connection of the answers given by the participants were forming themes. The identified themes were allocated codes and represented in a matrix table.

Theme	**Code**
Tree diagram	A
Fundamental counting principles	B

None	C

Table 4.2: Matrix table representing areas in probability in which learners are experiencing problems

	Theme		
Teacher	**A**	**B**	**C**
MI01	√		
WC02	√		
MM03			√
SS04	√	√	
LMK05		√	

The matrix table indicates that learners are experiencing problems mostly in Tree diagrams, followed by the fundamental counting principle. It further indicates that some learners do not have issues with any sub-topic in probability.

4.5 CONCLUSION

This chapter gave insight into Grade 12 mathematics teachers' competencies in teaching probability. It further clarified those topics that teachers are comfortable teaching and areas in which learners are experiencing problems in probability. Lesson observations and semi-structured interviews were conducted with teachers from five different schools; findings were shared in the chapter. The findings will subsequently be discussed in Chapter 5.

CHAPTER 5
DISCUSSIONS OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

5.1 INTRODUCTION

The study's primary purpose was to investigate Grade 12 Mathematics Teachers' competencies in probability. A qualitative approach was employed, and an exploratory research design was followed. Data were collected through lesson observations and semi-structured interviews. This chapter will discuss research findings, and recommendations for further research will be suggested. Furthermore, a conclusion will be made based on the research findings.

This study was conducted to solicit answers to the primary question, "What are the teacher competencies that affect the performance of learners in the topic Probability?" and the secondary questions:

1. Which teaching methods do teachers employ in teaching Probability?
2. Which sub-topics of Probability are teachers comfortable teaching?
3. How do the teachers teach the sub-topics they are uncomfortable teaching?
4. How do the teachers address the areas where learners experience problems in Probability?

Interviews and observations have been conducted with five Grade 12 teachers from Mathematics Science and Technology Focus (MSTA) schools in Mpumalanga to find answers to the stated research questions.

5.2 RESEARCH FINDINGS

This section discusses the study's findings with data from lesson observations and semi-structured interviews. Data in this study were acquired in two phases. lesson observations were conducted to address the study question: What teacher competencies affect learners' performance in Probability? Interviews were conducted to determine which teaching methods teachers employ in teaching Probability. Which sub-topics of Probability are teachers comfortable teaching? How do the teachers

teach the sub-topics they are uncomfortable teaching? And finally, how do the teachers address the areas in probability in which the learners experience problems?

5.2.1 RQ1: Which teaching methods do teachers employ in teaching probability?

Lesson observations and semi-structured interviews were purposed to find out which teaching methods teachers employ in teaching probability. Five Grade 12 Mathematics teachers were interviewed. The findings from the interviews on methods teachers use in teaching Mathematics are summarised in Table 4.1**.**

Seven teaching methods were identified as methods employed by teachers in the teaching of probability. The following were the seven methods used by teachers: Learner-centred method, Questioning and answering method, Peer Teaching method, Demonstration method, Team-teaching method, Direct-teaching (Facilitation) method and Narrative method. Both the learner-centred and questioning and answering methods are used by three participants, Peer Teaching and Demonstration are employed by two and Team-teaching, Direct-teaching (Facilitation) and Narrative methods are used by one participant each.

5.2.1.1 Learner-centred method

In this study, it was found that three of the participants believed in the learner-centred approach as the best method of teaching probability, which means 60 % of the teachers employ the learner-centred method. According to Darsir (2018), in learner-centred teaching, teachers are not a conveyor of information; they give independence and responsibility to learners to interact with the provided content and learn independently. He asserts that teachers are viewed as guides, facilitators, and coaches in learner-centred teaching. Their role is to create an environment that nurtures learning, accommodates diverse learning styles, and motivates learners to take responsibility for learning. Similar studies conducted by Dole et al. (2016), Weimer (2013) and Norman and Spohrer (1996) indicate that in learner-centred teaching, the teachers talk less and focus on asking questions that provoke learners to enquire, they develop a lot of in-class assignments that assist learners apply cognitive skills and create their own learning. Contrary to what learner-centred

teaching is, according to these studies, during lesson observations, the researcher found that the three teachers were mostly talking. They focused on delivering content, and learner involvement was very minimal.

5.2.1.2 Questioning and answering method

Like the learner-centred teaching method, 60 % of the teachers indicated using the questioning and answering method in their probability teaching. That is three of the five teachers. Dahal, Luitel and Pant (2019) state that generally, there are two types of teacher questions in a Mathematics classroom: low-level and high-level. Low-level questions are closed, direct, knowledge and recall questions, whilst high-level questions are open-ended, evaluative and probing. They indicate that asking learners questions that slot in both lower and higher levels would facilitate learning in mathematics. Herbel-Eisenmann and Breyfogle (2005) are of the view that questions like “Is there another way to represent or explain what you are saying?” are the types of questions that promote deeper mathematical thinking.

In the researcher’s lesson observations, teachers did not mostly ask questions during the lessons but at the end as homework. The two teachers who asked questions, LMK05 and MM03, needed sums to be worked out using the fundamental counting principle.

LMK05 asked the following question to the learners (Figure 5.1):

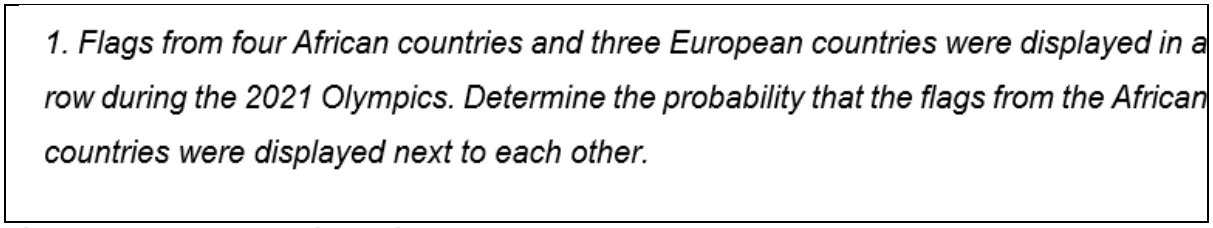


Figure 5.1: LMK05 question to learners

The topic for the day was the fundamental counting principles of probability; the question asked by the teacher was very appropriate because it asked learners to apply two skills: firstly, the application of the fundamental counting principles to determine

outcomes of an event which they learned in that particular day; and how to calculate Probability of an event which they have studied previously in the earlier grades.

The question below were given to the learners by Teacher MM03 at the end of her lesson (Figure 5.2):

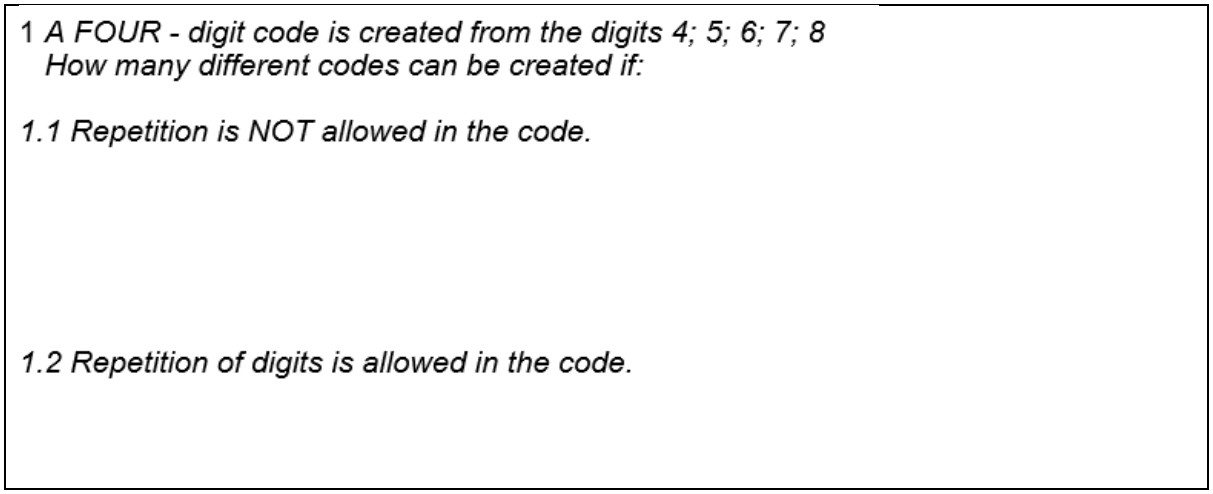


Figure 5.2: MM03 question to learners

The question asked by teacher MM03 was also good since, in working out the solutions, learners were required to apply the fundamental counting principles of probability, which they had learned on that particular day. Generally, the two questions asked by the teachers were significant because they reinforced the understanding of the concept of the fundamental counting principles taught on the day of observations.

5.2.1.3 Peer teaching method

The results of this study revealed that two teachers used peer teaching in the teaching of the topic of probability. That is 40 % of the participants. Ten Cate and Durning (2007) define Peer teaching as an educational setting where a learner teaches one or more fellow learners. According to Rubin and Hebert (1998), collaborative peer teaching is supported by three theoretical perspectives: Cognitive approach, motivational theory and social context. The cognitive approach emphasises information processing strategies, and learners can organise information, make connections, apply it in a new context and convey it to their classmates. In that way, learning is maximised.

On the other hand, motivational theory focuses on how learning is initiated and sustained; it believes in utilising innovative methods to give the responsibility for learning back to the learners. Lastly, the social context believes in dialogue as the most conducive environment appropriate for learning; teachers share responsibility for the topic with learners, allowing them to plan and present certain parts of the topic to their peers under their supervision. This aligns with the theory of didactical situations, which guided this study, as it emphasises that the teacher's role in a classroom is to create an inquisitive environment for the learners, enabling them to create their own knowledge actively. However, none of the two teachers employed peer teaching during the researcher's lesson observations. Learners' understanding of probability would be enhanced if teachers engaged in peer teaching in their classroom, thus allowing learners to teach each other. Abdelkarim and Abuiyada (2016) found that the peer teaching strategy is a dynamic means by which teachers can increase learners' mathematical achievement. Peer teaching is of great advantage to the learners because it positively affects their intellectual and moral values, increasing their ability to express their own ideas and improving their mastery of various concepts and time management; more importantly, it gives them a sense of responsibility, improving their self-confidence and self-discipline (Vasay 2010).

5.2.1.4 Demonstration method

One of the participants in this study, MM03, indicated that she employs a demonstration teaching method. Indeed, on the day of the observations, teacher MM03 invited five learners and demonstrated the application of the fundamental counting principle of probability. Onyeka and Okoye (2023) found that compared to learners taught with the deductive method, learners who were taught with the demonstration teaching method performed better in Mathematics. They further recommended that teachers employ demonstration teaching methods to reduce poor learner performance in mathematics. Figure 5.3 is an excerpt from the researcher 's interview with teacher MM03, where she indicated that she uses the demonstration method in her teaching of Mathematics and the topic of Probability.

TG: *What teaching methods do you use in teaching Mathematics?*

MM03: *Narrative, questioning and answer and demonstration*

TG: *Which of the teaching methods you mentioned are more appropriate for teaching probability?*

MM03: *Narrative and demonstration*

Figure 5.3: Excerpt from the researcher's interview with teacher MM03

5.2.1.5 Team teaching method

One of the five participants indicated that they employ team teaching. Buckley (1999) states that team teaching involves several teachers working cooperatively to facilitate learning. He states that the main aim of team teaching is to improve the quality of teaching and learning by moving from individual instruction to a team one. Buckley indicates that implementing team teaching is not that easy because it involves a lot of administration; teachers must discuss the goals together, plan individual lessons, and present them together. In all the five lessons observed by the researcher, team teaching was not implemented; teachers taught individually.

5.2.1.6 Direct teaching method

Ewing (2011) states that Direct instruction is based on the view that every learner can do well academically if they get proper instruction, and its focus is on the objectives of a lesson. In a similar study, Al-Makahleh (2011) indicates that in the direct teaching strategy, the focus is on procedures teachers follow to teach step-by-step skills learners must learn, not allowing learners to explore and experience learning independently. Only one teacher said she uses direct teaching in her probability teaching. The researcher observed that, in a way, all five teachers incorporated this teaching method in their teaching; their main focus was on achieving the lesson's objectives.

5.2.1.7 Narrative method

According to the study's findings, only one teacher prefers the narrative teaching method**.** Moore (1988) believes that the narrative teaching method involves storytelling, simulation, use of games, dramatisation and ritual re-enactments, which could be a good method of teaching probability if appropriately implemented by teachers; it is the method that makes mathematics enjoyable. According to Zazkis and Liljedahl (2009),

> *"We tell stories in the mathematics classroom to achieve an environment of imagination, emotion, and thinking. We tell stories in the mathematics classroom to make mathematics more enjoyable and more memorable. We tell stories in the mathematics classroom to engage students in a mathematical activity, to make them think and explore, and to help them understand concepts and ideas."*

5.2.2 RQ2: Which sub-topics of probability are teachers comfortable to teach?

Grade 12 Mathematics teachers in South Africa need to be competent in the following concepts of probability, which are examined in the NSC:

- Mutually exclusive events and complementary events;
- The identity for any two events A and B: P (A or B) = P(A) + (B) - P (A and B);
- Dependent and independent events;
- Venn diagrams, contingency tables and Tree diagrams as aids to solving probability problems (where events are not necessarily independent);
- The generalisation of the fundamental counting principles; and
- Solving probability problems using the fundamental counting principle (DBE, 2011).

When asked which sub-topics in the topic of probability they were comfortable teaching, participants indicated their capabilities on the five sub-topics taught: Venn diagrams, mutually exclusive events and complementary events, contingency tables, the fundamental counting principle, and tree diagram. Their responses to the question are summarised in Figure 4.7 in Chapter 4. Three of the five participants indicated they were comfortable teaching the fundamental counting principle. On the other hand, two participants are comfortable teaching Venn diagrams and Tree diagrams. Only one participant confirmed that he is comfortable teaching mutually exclusive and

complementary events, as in contingency tables. According to the DBE NSC diagnostic reports, learners are not performing well in the fundamental counting principle. Figure 1.3 indicates an average learner performance of 21 % on the sub-topic in the 2022 NSC examinations. However, 60 % of the participants indicated they were comfortable teaching fundamental counting principles; this is in line with Awuah (2018), who found that learners are not performing well in the use of Tree diagrams, contingency tables, and fundamental counting principles in comparison to other sub-topics of Probability taught in Grades 10 to 12 in South Africa.

5.2.3 RQ3: How do the teachers teach the sub-topics they are uncomfortable teaching?

The results of this question revealed that some participants are comfortable teaching all sub-topics in probability, whilst others are not. Two of the participants, SS04 and LMK05, indicated they are comfortable teaching all sub-topics. On the other hand, it was very interesting to find out that the other three participants prefer to ask other teachers, even from other schools and subject specialists, to teach for them when they are uncomfortable teaching the sub-topic; that is the outsourcing of teachers. Teacher MI01 referred to that as team teaching. Even though teacher LMK05 indicated that he is comfortable teaching all sub-topics, he added that he uses videos and animations to teach sub-topics he is uncomfortable teaching.

5.2.3.1 Outsourcing of teachers

It was found in this study that two teachers prefer to outsource teachers from other schools to assist them on sub-topics they are not comfortable teaching. Makgaga and Sepeng (2014) show that teacher outsourcing positively impacts learner performance. Through semi-structured interviews with learners, their study revealed that learners only got to understand the topic of probability and other topics like data handling when guest teachers taught them in their matric year.

5.2.3.2 Use of videos and animations

One of the teachers indicated that he is using videos and animations to teach the sub-topics that he is uncomfortable teaching. Rachmavita (2020) indicated that learning motivation can be increased in a mathematics classroom using media-based video animation. The same view is held by Luzón and Letón (2015), who asserts that the appropriate inclusion of animations in mathematics teaching stimulates learning abilities. Using videos and animations would make learners understand Probability much better as their learning capabilities would be inspired. Learners would not easily forget what they have seen in videos and animations; hence, learning would be enhanced if they were used in teaching and learning.

Weinberg and Martin (2020) suggested a framework for utilising videos that will lead to substantial learning in a classroom. They assert that the video watching should be divided into three sections: the launch, the watch and the debrief. In brief, they suggest learners talk about the concept to be learned in the video, perhaps even work on a problem and a solution that could be part of the contents of the video. They indicate that the second phase, the watch, is where learners watch the video, take notes and answer questions to be submitted to the teacher later. Lastly, in the debrief phase, they advise that learners share and discuss the concepts they have learned, including deliberations on questions they had during the second phase of watching, assisting each other in comprehending the concepts better and creating learning.

5.2.4 RQ4: How do teachers address the areas in which the learners experience problems within probability?

5.2.4.1 Outsourcing

It was established in this study that one teacher, teacher MI01, who deals with topics he is uncomfortable teaching, prefers to outsource other teachers to address areas with which the learners experience problems in probability. Makgaga and Sepeng (2014) found that learners got to understand the topic of probability and other topics like data handling when guest teachers taught them in their matric year. That makes outsourcing a good strategy to assist learners in performing well in areas where their teachers are experiencing problems.

5.2.4.2 Peer teaching

On the other hand, teacher LMK05 uses a peer teaching method to deal with those areas. He indicated that he groups the learners and requests one of them to present the area of the topic learners find problematic. According to Maheady (1998) and Topping and Ehly (1998), the advantages of peer teaching include high levels of academic performance, improved interpersonal relations between learners, and better individual and social development. A study by Gan and Hong (2010) revealed that students who engaged in peer teaching achieved more in mathematics than those who did not; they further asserted that peer teaching encourages self-efficacy and increases interest in learning mathematics. It would greatly benefit the learners if teachers could employ peer teaching in teaching mathematics and the topic of probability in particular.

5.2.4.3 Extra classes

It was further found in this study that the other three teachers, meaning 60 % of the participants, use extra classes to deal with areas where the learners experience problems within probability. Instead of assisting learners in improving performance, extra classes place tremendous pressure on the learners and the teachers and should be restricted (Santhi, 2011). On the contrary, Selamat et al. (2012) found that extra classes can yield improved learner academic performance, and learners perceive extra classes as highly effective. They state that extra classes should be utilised to revise what was learned instead of introducing new concepts.

5.2.5 The main research question

The responses to the four secondary questions assisted in answering the main research question: What teacher competencies affect learners' performance in Probability?

This study investigated Grade 12 Mathematics teachers’ competencies in the topic of probability. The main focus of this study was the three competencies: teacher knowledge, skills, and attitude and personality. This study reached its conclusion with the assistance of two data collection approaches: semi-structured interviews and

lesson observation, both of which played a key role in gathering relevant information. TDS, used as the theory that guided this study, provided the researcher with theoretical constructivism, as the theoretical lens used in this study, provided the researcher with the theoretical understanding of the roles played by both the teacher and a learner in a classroom. In terms of teacher knowledge, teachers demonstrate sufficient mastery of content but lack knowledge of mathematical content pedagogy. More often, teachers did not clearly specify the lesson aims at the start of the lesson. They mostly did not make clear, practical demonstrations.

On the other hand, there was minimal demonstration of teacher skill competency by the teachers; they seldom involved learners during the lesson, and they focused more on delivering the subject matter and route learning. Generally, learners were not encouraged to think critically, a crucial element in understanding probability. The pedagogical knowledge needed to teach probability is vital in teaching the topic because universal ideologies valid for other areas of mathematics are not always appropriate (Batanero et al., 2004). They further indicate that teachers are supposed to be aware of the different meanings of probability and philosophical controversies around them, not only focusing on presenting varying probabilistic concepts and their applications, which makes the teaching of probability more challenging. However, teachers were mostly audible enough and upheld a friendly and respectful teacher-student relationship.

There were more contradictions between what participants indicated during the interviews than what was observed. Three teachers said they were using the learner-centred method, but that is not what took place in a classroom; they were standing in front of the learners, talking all the time. Again, three of them indicated questioning and answering as their preferred teaching method; however, that did not happen during the lesson; learners were asked a maximum of just two questions to check if they understood.

5.3 RECOMMENDATIONS

5.3.1 Recommendations on the teaching of probability

It is recommended that teachers focus on teaching methods that encourage learner involvement when teaching the topic of probability. Teachers should refrain from focusing on the delivery of content knowledge and assist learners with activities and tasks that will encourage them to be curious and create knowledge and skills on their own.

5.3.2 Recommendations for future research

A little has been said in the literature about teaching methods appropriate for teaching the topic of probability. Future researchers may look into this topic and recommend suitable methods for teaching probability.

5.4 LIMITATIONS OF THE STUDY

The researcher chose secondary schools that are doing only mathematics in Mpumalanga. Other schools in the province offer mathematics and Maths Literacy, which were not part of the study. In some of those schools, learners are performing very well in mathematics. Perhaps the findings of this study could have turned out differently if they had been included. The convenience of accessing mathematics-focused schools channelled the researcher.

5.5 CONCLUSION

It was established in this study that teachers do not have a problem with content knowledge in the teaching of probability. The major challenge is the teaching methods and competencies required to teach the topic to demystify it to the learners. Of the three competencies observed through lesson observation, teachers are doing well in some aspects of teacher knowledge; they teach according to the prescribed curriculum and demonstrate sufficient mastery of content. The challenge is in the knowledge of mathematical content pedagogy; teachers did not make clear, practical demonstrations. On teacher skills, teachers are performing well in classroom

management but lacking in learner involvement. Lastly, regarding teacher attitude and personality, teachers are confident in teaching the topic of probability, but learner involvement in encouraging learners to think critically remains a challenge.

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ANNEXURES

Annexure A: Ethical Clearance Certificate

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

20-Jun-2022

Dear Mrs Tshehlane Koma

Application Approved

Research Project Title:
An investigation of Grade 12 mathematics teachers' competencies in the topic of probability.

Ethical Clearance number:
UFS-HSD2022/0354/22

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

Dr Adri du Plessis
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Annexure B: Interview Schedule

SEMI-STRUCTURED INTERVIEW SCHEDULE

Interviewee	School	Contact Number	Date of interview	Time

INTERVIEW QUESTIONS:

1. Which teaching methods do you use in teaching Mathematics?
2. Which of the teaching methods you mentioned are more appropriate for teaching probability?
3. Mention the sub topics in probability that you remember, please elaborate on skills and concepts taught in these sub topics.
4. From the sub topics that you mentioned, which ones are you comfortable to teach?
5. How do you teach the sub topics that you are not comfortable with in probability?
6. Which topics/sub-topics in probability do learners experience problems?
7. How do you address the topics/sub-topics that learners experience problems with in probability?
8. Is there any other thing that you want to tell me regarding the teaching of probability?

Annexure C: Lesson Observation Sheets

OBSERVATION SHEET

Date of observation..... **Grade observed.....**

Observer..... **Teacher code .....**

COMPETENCIES		INDICATORS
Teacher knowledge	Mathematical content knowledge	• Teaches according to prescribed curriculum • Demonstrates sufficient mastery of content • Clearly presents and explains concepts and skills
	knowledge of mathematical content pedagogy	• specifies clearly the lesson aims at the start of the lesson • Teaches in a well-structured mode • Displays evidence of teacher preparation • Makes clear, practical demonstrations
Teacher skills	classroom management	• Make sure the lesson proceeds in a well-ordered manner • utilizes the time for teaching and learning efficiently
	Learner involvement	• Involves all learners in the lesson • Checks whether learners have understood the subject material • Encourages learners to do their best • Gives activities that stimulate learners to take an active role in the lesson.
	communication skills.	• Gives clear instructions to learners • Audible enough
Teacher attitude and personality	Motivated	• Exhibits Confidence throughout lesson presentation • Displays composure, dignity, voice control, and insight
	Believe in	• Makes positive and supportive statements to students • Upholds a friendly and respectful teacher-student relationship
	patient	• Offers enrichment and/or remediation where needed
	Curiosity	• Encourages learners to think critically

Observer's notes

COMPETENCY	OBSERVATION
Teacher knowledge	
Teacher skills	
Teacher attitude and personality	

Annexure D: Consent Form

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

CONSENT TO PARTICIPATE IN THIS STUDY

I, the undersigned,

_____ (*participant's full names to be included*), (the "**Participant**")

confirm that I voluntarily agree to participate in the research study referred to as "*An investigation of Grade 12 mathematics teachers' competencies in the topic of probability*"

in relation to Education and which Study is being conducted by

Tshehlane Gladys Koma

I, the undersigned Participant, further confirm that–

1. the Researcher has explained the nature, procedure, potential benefits and anticipated inconvenience of my participation in the Study;
2. I have read (or had explained to me) and understood the Study as explained in the attached information sheet;
3. I have had sufficient opportunity to ask questions and am prepared to participate in the Study;
4. I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);
5. I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information in order to conduct the Study and any related activities in relation thereto;
6. I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer or otherwise process, as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein;
7. I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and deidentified at such stage;
8. I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other Higher Education Institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above applying.

I, the Participant, agree to the recording of the *Interview and Lesson observation*

Full Name of Participant: _____

Signature of Participant: _____ Date: _____

Full Name(s) of Researcher(s): _____

Signature of Researcher: _____ Date: _____

205 Nelson Mandela Drive/Rylaan, Park West/Parkwes, Bloemfontein 9301, South Africa/Suid-Afrika
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Annexure E: Approval from Mpumalanga DoE to Conduct Research

education
MPUMALANGA PROVINCE
REPUBLIC OF SOUTH AFRICA

Ikhamanga Building, Government Boulevard, Riverside Park, Mpumalanga Province
Private Bag X11341, Mbombela, 1200.
Tel: 013 766 5552/5115, Toll Free Line: 0800 203 116

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

Ms TG Koma
University of Free State
Email: komagladys18@gmail.com

RE: "AN INVESTIGATION OF GRADE 12 MATHEMATICS TEACHERS COMPETENCIES IN THE TOPIC OF PROBABILITY"

Your application to conduct research study was received and is therefore acknowledged. The tittle of your research project reads: **"An investigation of grade 12 mathematics teachers competencies in the topic of probability".** I trust that the aims and the objectives of the study will benefit the whole department especially the beneficiaries. Your request is approved subject to you observing the provisions of the departmental research policy which is available in the department website. You are requested to adhere to your university's research ethics as spelt out in your research ethics.

In terms of the research policy, data or any research activity can be conducted after school hours as per appointment with affected participants and COVID -19 regulations to observed. You are also requested to share your findings with the relevant sections of the department so that we may consider implementing your findings if that will be in the best interest of the department. To this effect, your final approved research report (both soft and hard copy) should be submitted to the department so that your recommendations could be implemented. You may be required to prepare a presentation and present at the departments' annual research dialogue.

For more information kindly liaise with the department's research unit @ 013 766 5124/5148 0r n.madihlaba@mpuedu.gov.za
The department wishes you well in this important project and pledges to give you the necessary support you may need.

Moyane

MRS LH MOYANE
HEAD: EDUCATION

08 / 05 / 2022
DATE

MPUMALANGA
THE PLACE OF THE RISING SUN

Annexure F: Letter from Language Editor

Michelle Woolley

WRITER EDITOR PROOFREADER TRANSLATOR

Bachelor of Library and Information Science: B.Bibl.
Reference & Research Librarian
Bachelor of Arts **Honours** in **Translation Studies and Editing**

Associate Member of Professional EDITORS' Guild (PEG)

CERTIFICATE OF EDITING

This letter certifies that I have edited the Dissertation detailed below.

Title:

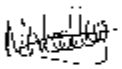
AN INVESTIGATION OF GRADE 12 MATHEMATICS TEACHERS' COMPETENCIES IN THE TOPIC PROBABILITY

Author:

TSHELANE GLADYS KOMA

Student Number: 2011004690

Regards
Michelle Woolley



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Professional EDITORS Guild