TEACHING STRATEGIES USED TO TEACH DATA HANDLING IN GRADE 10: A CASE OF TWO SCHOOLS IN THE BOJANALA DISTRICT IN RUSTENBURG

by

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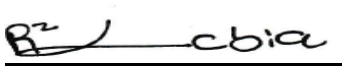

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DEDICATION

I dedicate this work to my family, whose love, patience, and encouragement have been my pillars of strength. Their unwavering belief in me helped me stay confident and persevere through challenges. To my parents, this is a tribute to the sacrifices you made to make my dreams possible. May God richly bless you.

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ABSTRACT

The aim of this study was to investigate the effectiveness of teaching strategies for Grade 10 Data Handling with a particular focus on improving performance in South Africa, where learners continue to struggle despite various educational interventions. Poor results in Mathematics, particularly in Data Handling, have become a significant concern, especially in the Bojanala district of North West Province. Although teachers in this region are committed and support learners, the issue of low performance persists.

This study employed a mixed-methods research design to evaluate the effectiveness of various teaching methods. The study population comprised two teachers and Grade 10 learners from two selected schools in the Bojanala District. A total of 60 learners participated, with 30 learners assigned to the experimental group and 30 to the control group. To ensure the sample captured a wide range of perspectives on teaching strategies for teaching Grade 10 Data Handling, a simple random sampling method was employed. Pre-tests and post-tests were administered to measure learners' understanding of the concepts. Data were collected through semi-structured interviews and lesson observations. These methods were employed in alignment with the hypothesis to gather comprehensive insights into the effectiveness of the teaching strategies.

The results revealed a significant improvement in the experimental group's performance, where the intervention had a greater impact than the control group. This suggests that the experimental group developed a more comprehensive understanding of Data Handling concepts as a result of the intervention. The post-test scores supported this finding, with the experimental group's mean score increasing to 18.83, while the control group scored 16.30, showing a significant difference ($t = -1.1032$; $p = 0.04$) at a 95% confidence level. The experimental group's substantial progress, reflected in an 11.53-point increase from the pre-test to the post-test, contrasted with the control group's 8.8-point improvement, indicating that although the control group showed improvement, the intervention had a more pronounced effect on the experimental group. This highlights the effectiveness of the intervention, particularly in areas where the learners initially struggled. These findings suggest that targeted interventions led to significant improvements in learners' understanding of challenging concepts, highlighting the potential value of incorporating such strategies in similar educational settings.

Qualitative analysis of the outcomes revealed that the use of Collaborative Group Work significantly enhanced learner engagement and performance in Data Handling tasks within the experimental group. Learners in this group demonstrated more active participation and improved problem-solving skills.

The study also highlighted the effectiveness of blending George Polya's Problem-solving strategies with Vygotsky's theories in a CGW environment for teaching Data Handling at the Grade 10 level. These strategies enhanced academic performance and fostered a deeper understanding of data related concepts, which are crucial in today's data-driven world. The findings suggested that the combined use of CGW, Polya's PS approach, and Vygotsky's collaborative learning principles could significantly improve the teaching and learning of DH in Grade 10.

Keywords: cooperative group work; data handling; learner performance; mathematics education; problem-solving; scaffolding; teaching strategies; zone of proximal development

LIST OF ABBREVIATIONS AND ACRONYMS

ATP	Annual Teaching Plan
BEEI	Basic Education Employment Initiative
CEDU	College of Education
CG	Control Group
CGW	Collaborative Group Work
CPS	Collaborative Problem-Solving
DBE	Department of Basic Education
DH	Data Handling
DoE	Department of Education
EG	Experimental Group
LTSM	Learning and Teaching Support Materials
MPSP	Mathematical Problem-Solving Protocol
NSC	National Senior Certificate
PISA	Programme for International Student Assessment
PS	Problem Solving
S1	School 1
S2	School 2
SACE	South African Council for Educators
SBA	School-Based Assessment
SGB	School Governing Body
T1	Teacher 1 (from School 1)
T2	Teacher 2 (from School 2)
TIMSS	Trends in International Mathematics and Science Study
ZPC	Zone of Proximal Construction
ZPD	Zone of Proximal Development

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CHAPTER ONE: OVERVIEW OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND

Data Handling (DH) is a crucial component of mathematics education, as it connects learners to real-world contexts and promotes the development of critical thinking skills (Botha & Makina, 2023). Moodley and Msimanga (2023:112) highlight that DH plays a crucial role in enabling learners to develop a deeper conceptual understanding of mathematics. Bill (2021) emphasises that the relevance of data analytics extends beyond specialised professions, influencing multiple facets of everyday life. Seiner (2021:45) highlights that the ability to interpret and manage data is essential not only for career readiness but also for informed decision making in a data-driven society. Smith and Johnson (2020:33) assert that individuals are increasingly exposed to data in their daily lives, from health tracking applications to personal finance tools, reinforcing the importance of developing strong data literacy skills from an early age. The authors further emphasise the significance of DH in cultivating critical thinking, enhancing problem-solving (PS) skills, and facilitating sound decision making.

DH in education encompasses key stages such as data collection, analysis, summarisation, and presentation each requiring the development of higher order thinking skills (Moodley & Msimanga, 2023:78). Botha and Makina (2023:115) emphasise that these cognitive skills should be introduced at an early stage, as they are foundational to critical reasoning. Despite its significance, DH often receives limited instructional focus within the curriculum. Recent international assessments, such as Trends in International Mathematics and Science Study (TIMSS), continue to highlight poor learner performance in DH related competencies, particularly in the analysis, construction, and interpretation of graphs (Spaull & Jansen, 2024). Highlighting the urgent need to improve data literacy education in schools.

DH is a critical component of the Grade 12 National Senior Certificate (NSC) Mathematics examination, accounting for approximately 20–25% of the final assessment (DBE, 2023). Despite its significant weighting, learner performance in this component remains consistently low, revealing ongoing difficulties in understanding and applying statistical concepts (Botha & Makina, 2023). Research attributes this underperformance to gaps in conceptual understanding and a predominant focus on procedural methods rather than developing statistical reasoning (Spaull & Jansen, 2024; Mhlolo, 2022). The table below illustrates estimated learner achievement trends in response to increasing curriculum complexity and cognitive demand over the five years from 2020 to 2024.

Year	2020	2021	2022	2023	2024
Percentage	75%	78%	70%	65%	60%

Between 2020 and 2021, learners demonstrated relatively strong foundational competence in DH, with an improvement in performance from 75% to 78%. These results suggest that learners were confident in basic statistical concepts such as measures of central tendency (mean, median, and mode). However, early signs of difficulty emerged in tasks involving variability, including range and interquartile range, indicating limited conceptual depth in data interpretation (Spaull & Jansen, 2024).

While the curriculum's foundational focus initially succeeded, gaps emerged as assessment demands evolved. In 2022 and 2023, the introduction of more complex and context-rich content, such as probability, data from real-world scenarios, and ethical reasoning within digital platforms, led to a noticeable decline in learner performance, a drop from 70% to 65%. Learners showed isolated strengths, particularly in probability (80%) and ethical considerations (85%), but struggled with tasks that required integrated thinking and multi-step data analysis (Botha & Makina, 2023; Mhlolo, 2022). This pattern reflects broader challenges in curriculum delivery and teacher preparedness to support critical data literacy.

By 2024, the emphasis had shifted toward interpreting online datasets and addressing the ethical implications of data use in a digital society. While learners performed well on ethics related items, overall DH achievement dropped to 60%, the lowest in five years. This downward trajectory reveals a growing disconnect between curriculum expectations and learners' statistical fluency. Possibly exacerbated by inconsistent teacher training, inadequate instructional resources, and evolving assessment practices. Moodley and Msimanga (2023) emphasise the urgent need for pedagogical innovation, curriculum recalibration, and targeted teacher support to enable learners to navigate both foundational and advanced statistical concepts.

The TIMSS (2020) and Programme for International Student Assessment (PISA, 2024) results show that the country ranks at the bottom of global assessments, particularly in mathematics, where South Africa's scores consistently fall below 40%. Top performing countries such as Singapore, Finland, and Hong Kong achieve high rankings in these assessments (Bill, 2021; Mun et al., 2018). The (ibid) credits their success to effective teacher professional development, a well-structured curriculum, and a focus on critical thinking and PS. On the contrary, South Africa's education system, particularly in districts like Bojanala, continues to face considerable challenges in fostering a strong, learners centred learning environment that encourages engagement and the mastery of complex mathematical concepts.

The persistent performance gaps in mathematics in South Africa can largely be attributed to deficiencies in teaching methodologies and teacher competence. Studies highlight persistent challenges in mathematics education, including reliance on outdated teaching methods,

limited pedagogical content knowledge, and insufficient professional development (Spaull & Jansen, 2024; Moodley & Msimanga, 2023; Botha & Makina, 2023). All of which hinder learner success. Despite various government-led curriculum reforms, substantial improvements in learner outcomes remain elusive, indicating that more targeted and systemic educational interventions are urgently required.

1.2 RATIONALE FOR THE RESEARCH

This research study was motivated by the critical need to improve Data Handling competencies among learners in the Bojanala district of Rustenburg. Persistent underperformance in this area highlights systemic challenges in teaching methodologies, resource availability, and curriculum alignment. By investigating the root causes of these challenges, the aim of the study was to provide solutions that enhance instructional practices and improve learner outcomes.

The findings will hold significant value for multiple stakeholders in the educational ecosystem. Learners will benefit from improved instructional strategies and access to effective Learning and Teaching Support Materials (LTSM), which will foster better comprehension and application of Data Handling skills. Teachers and school administrators will gain evidence-based insights into pedagogical approaches that optimise teacher-learner interactions. The study will also inform targeted professional development programmes to strengthen instructional delivery. Additionally, curriculum developers and policymakers will receive data-driven recommendations to refine LTSM, align teaching resources with technological advancements, and advocate for equitable access to learning tools.

A mixed-methods approach, incorporating input from teachers, learners, and administrators, this study analysed current practices, identified gaps, and proposed interventions to enhance Data Handling education. Ultimately, the research aims to contribute to policy reforms that promote inclusive, high-quality education in the Bojanala district, ensuring that all learners are equipped with essential 21st-century skills.

1.3 PROBLEM STATEMENT

Poor results in Mathematics, particularly in Data Handling, are evident in the NSC results, with numerous learners struggling to grasp key concepts (DBE, 2020:197). Core (2022:45-50) argues that teachers who master effective Data Handling teaching strategies can significantly enhance learners' mathematical knowledge and overall performance. However, Spaull and Jansen (2024:183) reveal that many teachers fail to utilise various teaching methods when instructing Data Handling, which limits learners' understanding of the subject. Mhlolo and Graven (2023:183) further emphasise that teachers' attitudes towards the strategies they

employ directly influence learner achievement. Many teachers do not vary their teaching approaches, even when learners do not grasp the concepts. The absence of diverse teaching strategies presents a significant barrier to improving learner comprehension of Data Handling. Jenkins (2020:20-25) notes that teachers often overlook alternative methods when learners face challenges, impeding the learning process. This issue is exacerbated by a lack of effective teaching strategies, which negatively impact learners' ability to master Data Handling.

Countries such as Singapore, Finland, and Estonia have successfully integrated PS approaches into their mathematics education, improving learner engagement and performance. According to Lim and Lee (2023), Singapore's PR1ME Mathematics Programme incorporates metacognitive strategies and a PS focus that promotes deep conceptual understanding in Data Handling. In Finland, Sahlberg and Saloviita (2024) note that student led inquiry and problem based learning are central to the curriculum, enabling learners to develop critical thinking and apply statistical concepts in real-world contexts. Similarly, Kikas and Tamm (2023) report that in Estonia the education system emphasises problem-solving and digital literacy in mathematics instruction, helping learners master Data Handling.

In contrast, South Africa relies predominantly on traditional teaching methods, where rote learning and teacher centred instruction remain common in mathematics classrooms (Botha & Makina, 2023). Moutlana and Modise (2024) argue that this approach limits learners' opportunities to engage in meaningful PS, particularly in topics such as Data Handling. Jita and Lekhetho (2023) assert that the absence of inquiry based pedagogy in South African schools contributes to persistent underperformance in mathematics. Highlighting the urgent need to adopt more innovative, learner centred strategies.

The DBE (2022:115) indicate that teachers who have recently undergone training in effective teaching practices, despite having less experience, tend to outperform their more experienced colleagues. Highlighting the importance of ongoing professional development for teachers. The problem of inadequate performance in Data Handling is particularly concerning in the Bojanala district, where the performance gap may not always be apparent at lower grade levels (DBE, 2023:45-50). Interestingly, subjects such as Accounting and Physical Science yield better results than Mathematics, even though a solid foundation in Mathematics is crucial for learners to excel in these subjects.

Despite the efforts made, the NSC results in the Bojanala district continue to decline (DBE, 2022:32-35). The district has implemented intervention programmes such as ensuring the library is functional, offering classes from Monday to Sunday, providing matric learners with tablets and data bundles, and the "Silala la programme," which translates as "we sleep here,"

along with “Last Push” and winter and spring camp classes. Nevertheless, mathematics results continue to decline in the Bojanala district despite these interventions.

1.4 RESEARCH QUESTIONS AND HYPOTHESIS

1.4.1 THE EXAMINED HYPOTHESIS

The study also examined the hypothis that were developed:

H_0: The application of Strategies does not affect the performance of Data Handling Grade 10 learners.

H_1: The application of strategies does affect the performance of Data Handling Grade 10 learners.

1.4.2 THE RESEARCH QUESTION

What teaching strategies are employed by Grade 10 Mathematics teachers to teach Data Handling in two selected schools within the Bojanala District?

Sub questions

The following sub-questions must be answered to resolve the main research question.

- How do teachers teach Data Handling to Grade 10 learners?
- What challenges do teachers encounter when teaching Data Handling practices?
- What strategies can teachers employ in Grade 10 to effectively teach Data Handling?

1.4.3 AIMS OF THE STUDY

To classify the deficiency of prior knowledge impacting teachers’ use of teaching approaches in Grade 10 Data Handling.

- To explore how teachers teach Data Handling.
- To establish the challenges that teachers experience in the teaching of Data Handling.
- To propose ways for teachers to enhance their strategies.

1.5 CHAPTER OUTLINE

CHAPTER ONE: OVERVIEW OF THE STUDY

CHAPTER TWO: THEORETICAL AND CONCEPTUAL FRAMEWORK

CHAPTER THREE: LITERATURE REVIEW

CHAPTER FOUR: RESEARCH METHODOLOGY

CHAPTER FIVE: PRESENTATION OF THE FINDINGS

CHAPTER SIX: DISCUSSION OF THE FINDINGS

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

1.6 CHAPTER SUMMARY

This chapter has established the foundational context of the study by introducing its background, rationale, research problem, aims, objectives, and key research questions. By defining essential concepts and delineating the scope of the investigation, this chapter has set the stage for a structured inquiry into the research topic. However, to deepen the scholarly grounding of the study, a robust theoretical and conceptual foundation is necessary to guide the analysis and interpretation of findings.

Chapter Two builds upon this by presenting the theoretical and conceptual frameworks that underpin the study. These frameworks serve as critical lenses through which the research problem is examined, ensuring alignment between the study's design and its interpretive approach. By drawing on established theories and relevant conceptual models, this chapter not only justifies the methodological choices but also clarifies the relationships among key variables.

CHAPTER TWO: THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

The previous chapter provided an introduction and contextual foundation for the study by delineating the problem statement, research purpose, objectives, and key research questions. Building on this groundwork, this chapter presents the theoretical framework that underpins and guides the study, offering a critical lens for conceptualising the research problem and interpreting its findings. A well-chosen theoretical framework supports the formulation of research questions and methodological decisions (Creswell & Creswell, 2018).

This chapter discusses Vygotsky's (1978) Social Constructivist Theory, with emphasis on the Zone of Proximal Development (ZPD), the Zone of Proximal Construction (ZPC), the three core components of the ZPD; the learner, the expert, and the task and the pivotal role of scaffolding in promoting cognitive development. Piaget's concepts of assimilation and accommodation are also considered, reflecting the dynamic process by which learners integrate new knowledge into existing cognitive structures. Furthermore, it examines George Pólya's PS strategy, which comprises the phases of understanding the problem, devising a plan, executing the plan, and evaluating the solution. The integration of these theoretical perspectives supports the implementation of collaborative group work within DH in the Mathematics curriculum, where learners engage in peer-supported, socially mediated learning experiences.

2.2 THEORETICAL FRAMEWORK

The theoretical framework of this study is grounded in a synthesis of contemporary and classical educational and cognitive theories, providing a foundation for exploring collaborative problem-solving in mathematics education. Central to this is Vygotsky's (1978) Social Constructivist Theory, which emphasises the ZPD and the pivotal role of scaffolding in learners' cognitive development. This theory highlights the importance of guided interaction between more knowledgeable peers and learners within the ZPD. Complementing this, Pólya's four-step problem-solving model, understanding the problem, devising a plan, executing the plan, and evaluating the solution, offers a structured approach to mathematical reasoning (Tractenberg et al., 2024). Multimedia Learning Theory emphasises the importance of visualisation strategies in mitigating cognitive overload and improving learners' understanding of abstract mathematical concepts. Piaget's concepts of assimilation and accommodation further explain how learners adapt and integrate new mathematical knowledge into existing cognitive structures. By combining these theoretical perspectives, the study provides a comprehensive framework for examining how scaffolded, collaborative

problem-solving activities can enhance learners' mathematical reasoning and skill development (Lee et al., 2024).

2.3 CONCEPTUAL FRAMEWORK

The conceptual framework of this study was developed to illustrate the dynamic interplay among peer support, visualisation strategies, CGW, and structured problem-solving models within the context of Grade 10 Data Handling (DH) in the mathematics curriculum. It posited that when more proficient learners supported their peers through structured CGW settings, scaffolded interactions facilitated the acquisition of problem-solving skills, particularly in DH and real-life mathematics applications.

Visualisation was identified as a critical tool for bridging abstract concepts and learner understanding, thereby reducing cognitive load (Sweller et al., 2011; Mayer, 2014). CGW provided the social and dialogic environment necessary for knowledge co-construction (Johnson & Johnson, 2017) and served as the operational platform for implementing Pólya's problem-solving strategy. The framework proposed that integrating these strategies resulted in enhanced learner engagement, improved mathematical reasoning, and increased capacity for applying mathematics in everyday contexts.

Recent advancements, such as the development of the Mathematical Problem-Solving Protocol (MPSP) offer tools to strengthen scaffolding and coherence across mathematics courses, aligning with the study's emphasis on structured problem-solving (Tractenberg et al., 2024), Additionally, the application of Large Language Models to generate tailored mathematical problems (Lee et al., 2024) suggested innovative approaches to integrating technology into mathematics education.

This context specific model aligned with the theoretical underpinnings and translated them into a practical structure for exploring the effectiveness of collaborative, scaffolded learning in mathematics education. The framework provided a foundation for analysing how peer-assisted learning, visualisation techniques, and structured problem-solving models collectively contributed to improved mathematical proficiency and real-world application skills among Grade 10 learners.

2.4 PROBLEM-SOLVING MODEL

This study's conceptual framework is grounded in George Polya's problem-solving methods, providing a systematic approach to teaching and understanding DH concepts. Polya's framework provides a step-by-step guide that helps learners break down complex problems, thereby enhancing their ability to tackle DH-related tasks effectively. This method promotes comprehension and facilitates the development of critical thinking skills essential for grasping

DH concepts, particularly in calculating the five-number summary. Polya's four-step structure comprises understanding the problem, formulating a plan, executing the plan, and assessing the solution, guiding learners in data organisation, data handling, computation, and evaluation of their outcomes. This framework elucidates the relationships between key variables, including data organisation, statistical measures, and mathematical procedures, while also supporting learners in improving their PS skills. The research aims to investigate how Polya's method enhances learners' capacity to engage with complex DH tasks, ensuring accuracy and fostering critical thinking (Nasution et al., 2021; Daulay & Ruhaimah, 2021).

2.4.1 George Polya's problem-solving stages

George Polya's theoretical framework consists of four essential stages: understanding the problem, devising a strategy, executing the plan, and evaluating the solution. It aims to enhance learners' problem-solving skills by breaking complex issues into more straightforward, manageable components, thus facilitating comprehension and resolution (Filimowicz, 2023). Polya (1945) emphasised that learners' difficulties in solving mathematical problems do not arise from a lack of knowledge but mainly from inadequate problem-solving guidance. By systematically following these four phases, learners can approach problems logically, fostering critical thinking and improving their ability to solve problems effectively (Arrahim, Sugiharti, & Damayanti, 2022). This dissection of complex problems ensures clarity, enabling learners to grasp concepts more quickly and deeply.

This study adopts Polya's model, as it aligns with enhancing learners' problem-solving skills in DH, particularly in operations involving equivalent calculations, addition, subtraction, and division. Chin et al. (2023) further assert that the theory emphasises the importance of cultivating essential problem-solving abilities, which include understanding the problem, formulating a strategy, implementing the plan, and evaluating the solution. By applying Polya's method, the study aimed to help learners systematically navigate mathematical tasks related to DH, thereby promoting both conceptual understanding and procedural fluency. The primary data findings in this study stem from activities that integrated these problem-solving steps, demonstrating how learners can enhance their mathematical proficiency through structured approaches (Daulay & Ruhaimah, 2021).

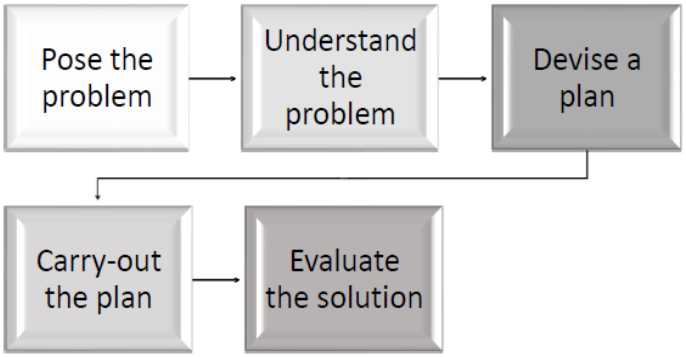

Figure 2.1: ***Polya's PS four-phase model*** (Fadipe (2017)

2.4.1.1 Understand the Problem

Understanding a problem requires learners to read and analyse the questions carefully. According to Chin et al. (2019), learners must synthesise the problem, decompose it into smaller components, and identify the key information. The primary task for both teachers and learners is to comprehend and interpret the problem (Chin et al., 2019). Learners need to grasp the essence of the question and extract the vital data required to solve it (Naghavi, 2015). This process is particularly critical in mathematics, where learners must connect abstract information with their prior knowledge to discover solutions (Chin et al., 2019). By thoroughly understanding the problem, learners enhance their critical thinking and become more adept at asking questions that clarify the issue, such as "What is this problem about?" "What information is necessary?" and "What steps can I take to solve the problem?"

Furthermore, when working with DH, learners must distinguish between organised and unorganised data and between grouped and ungrouped data to effectively address the problem. For instance, when calculating the five-number summary, if the data is unorganised, learners must first arrange it in ascending order prior to proceeding with the calculations. Understanding how to approach and organise data is vital for PS in DH. Learners should employ hints or strategies to guide their approach to the data, aiding them in identifying the correct steps for solving problems, such as determining the minimum, Q1, Q2, Q3, and maximum values. By tackling problems in this structured manner, learners are more likely to successfully calculate the five-number summary and demonstrate their grasp of the concept.

Example 1: Unorganised Data: 45, 22, 38, 12, 27, 55, 33, 18, 42, 50

Steps:

Understanding the Problem: Explain to learners that they need to calculate the five-number summary, but the data is currently unorganised.

Task: Ask learners to first organise the data in ascending order.

3. Organise the data: 12, 18, 22, 27, 33, 38, 42, 45, 50, 55

4. Solution: Min=12, Q1= 22, Q2= 35.5, Q3= Median= 45 & Maximum: 55

Example 2: Organised Data: 10, 15, 20, 25, 30, 35, 40, 45, 50

Steps:

Understanding the Problem: Explain that the data is already in ascending order, and learners are to calculate the five-number summary.

Task: Ask learners to identify the Min, Q1, Q2, Q3, and Min.

Solution Step 1: Min=10, Q1 =20, Q2=30, Q3=40 & Max= 50

Learners need to comprehend how the process differs from the initial activity, where data had to be organised beforehand. This organised data facilitates quicker identification of the five-number summary. These activities helped learners understand the importance of structuring data before calculating the five-number summary and how the process differs when dealing with grouped versus ungrouped data. By engaging with both categories of data, learners cultivate a deeper understanding of managing real-world data and applying statistical methods efficiently.

2.4.1.2 Devise the Action Plan

Once learners grasp the problem, they proceed to the crucial phase of developing a plan. During this phase, they decompose the problem into smaller, manageable components and reorganise the data using model diagrams, such as charts or tables, which have proven helpful in resolving similar issues (Pritchard, 2017). As Pritchard (2017) emphasised, this planning process is essential for effective problem-solving. Learners can formulate a robust plan only if they have access to the necessary resources; a lack of resources may hinder the planning process and lead to suboptimal solutions (Naghavi, 2019). Teachers play a pivotal role in supplying the appropriate information, such as data identification and comprehending the interrelationships between different pieces of data (Mavridis, Katmada, & Tsiatsos, 2017). An example of this is illustrated by calculating a five-number summary, where learners recognise the significance of arranging data in ascending order before extracting key values. This process not only aids them in organising the information but also accommodates various learning styles (Naghavi, 2019), enabling learners to appreciate different methods of approaching problems based on the provided data.

At this stage, learners begin to gain confidence in approaching various questions by applying structured methods to the data at hand. The ability to break down complex problems into smaller tasks and to organise data systematically allows learners to tackle different scenarios

more effectively. Using well organised models and methods, such as the five-number summary, helps learners develop strong PS skills that are adaptable to various contexts. This approach enhances comprehension of the subject and cultivates critical thinking, preparing learners to address many challenges they may encounter.

2.4.1.3 Carrying out the Plan

This involves implementing the proposed strategies through calculations, experiments, and diagrams to solve problems effectively (Mandina, 2018; Fitzgerald, 2019; Chirinda et al., 2020). Teachers play an important role in guiding learners to select the most suitable procedure from their pre-established plans. Rahman (2019) emphasises that teachers should support learners in identifying and applying the best methods, ensuring they utilise the correct approaches. At this stage, individual observation of progress and self-correction are crucial, as learners must evaluate their work and make adjustments accordingly (Tursucus et al., 2020). According to Banji (2017), initial plans often do not produce the desired results immediately, and learners should not be disheartened when facing failure. Instead, they should recognise that failure is part of the learning process and, with proper interpretation and adjustments, can lead to discovering the correct solution. This mindset fosters resilience and persistence, guiding learners to thoroughly and systematically navigate each phase of the PS process (Nyembe, 2020).

In calculating a five-number summary, learners can appreciate the importance of adequately organising data and adhering to structured procedures. For instance, learners can easily extract the five-number summary after arranging the data in ascending order. However, if the data organisation is faulty, they must return to Phase 1 and rectify the order before proceeding. This iterative process ensures learners do not rush through the PS steps and highlights the significance of completing each phase thoroughly. The trial, error, and correction process reinforces the notion that mistakes are a natural part of learning and that it is vital to master each step before advancing to the next.

For instance, when given a problem such as:

1. Given Unorganised Data: 34, 12, 27, 19, 49, 38, 49, 21, 52
2. Task: Ask learners to sort the data in ascending order.
3. Solution: Ascending order: 12, 19, 21, 27, 34, 38, 49, 49, 52

12	**19**	**21**	**27**	**34**	**38**	**49**	**49**	**52**
MIN		**Q1**		**Q2**		**Q3**		**MAX**

2.4.1.4 Evaluate Solution

Learners should engage in reflective thinking to assess their solutions effectively (Albay, 2019). Reflective self-evaluation can be guided by questions such as: "Do my answers make sense?" "Can I explore an alternative method to reach this solution?" and "How does this answer relate to the original problem?" These reflective questions encourage learners to critically analyse their answers and explore different problem-solving strategies. Polya's PS framework, comprising four clear stages, offers an organised method for enhancing mathematical PS abilities. According to Smith and Jones (2021), Polya's framework remains a key resource for strengthening learners' problem-solving skills. The four (4) steps guide learners through solving complex problems (Brown & Taylor, 2022). This theoretical framework has been shown to improve learners' ability to approach and solve problems with greater confidence and flexibility (Filimowicz, 2018).

2.4.2 PS Approach

Polya's PS approach is a widely recognised framework in mathematics education, particularly useful for guiding learners through solving mathematical problems, such as DH in Grade 10 (Albay, 2023). This approach aligns with an ontological perspective that views PS as an iterative and dynamic interaction between the problem and the solver (Nasution, Harahap, & Samosir, 2021). The key components of this perspective include: (i) the "problem space," referring to the context in which the problem exists; (ii) the "problem solver," who actively engages within this space; and (iii) "problem representation," which pertains to how the problem solver interprets and understands the problem (Daulay & Ruhaimah, 2021). These perspectives support the application of Polya's approach in evaluating the teaching of DH, providing a systematic method for learners to engage with complex data tasks, such as organising data and calculating five-number summaries.

2.5 SOCIAL CONSTRUCTIVISM

Social constructivism provides an ideal framework for fostering active learning by emphasising collaboration, knowledge co-construction, and meaningful engagement. According to Vygotsky (1978), learning occurs in two phases: initially through social interactions (interpsychological) and subsequently through internalisation (intrapsychological). This can be implemented by encouraging collaborative activities where learners work together to analyse and interpret data. For instance, learners could collaborate on projects that involve collecting, organising, and analysing data sets, such as survey results or trends in real-world scenarios. This interaction not only aids learners in constructing knowledge through discussions and negotiations of their findings but also allows them to apply prior knowledge from earlier grades. As endorsed by constructivist theorists, the cooperative aspect of the learning process

ensures that knowledge is not passively received but actively built through engagement with peers and the learning environment.

Furthermore, Constructivism highlights the importance of building new knowledge upon existing mental frameworks (Phillips, 1995), which is essential in DH instruction. For the learners, this translates to making connections between what they have previously learned and applying this knowledge to new, more complex data challenges. Teachers can facilitate this process through scaffolding, guiding learners through the initial stages of PS and gradually withdrawing support as learners gain confidence and independence. McLeod (2019) highlights this point, noting that engaging learners in real-world problem-solving enhances their understanding of concepts, enabling them to build confidence and take ownership of DH. This may involve using real-world data to address issues pertinent to learners' lives, such as analysing environmental data or interpreting social trends. By integrating prior knowledge with new experiences and encouraging collaboration, the learning process becomes dynamic and personalised, fostering a deeper understanding and retention of statistical concepts.

2.6 ZONE OF PROXIMAL DEVELOPMENT

The concept of ZPD is particularly relevant for developing effective pedagogical practices. As Vygotsky (1978) emphasises, learners can achieve higher levels of understanding with appropriate assistance, guidance, and collaboration. In DH, teachers can use scaffolding to guide learners through progressively more complex data analysis tasks, ensuring they move beyond their current ability level. For example, a teacher might begin by modelling the process of analysing a data set, demonstrating how to compute measures like mean, median, and mode, and then gradually guiding learners as they build confidence. This support helps learners bridge the gap between their current knowledge and their prospective development in DH, while also motivating them to independently apply statistical methods and increasingly complex data analysis.

Furthermore, strategies rooted in the ZPD can enhance the learning experience in DH by fostering cooperative learning and peer interaction (Silalahi, 2019). For instance, learners can be organised according to their varying levels of understanding, where more capable peers provide assistance and support to those in need. This collaborative approach enables learners to solve problems and encourages them to learn from one another’s thought processes. According to Knestrick (2012), targeted instruction that aligns with learners' ZPDs ensures they receive the right level of challenge and support. In DH, this might involve assigning tasks that are slightly beyond the learners' independent capabilities yet achievable with guidance, such as creating intricate data visualisations or interpreting multivariable data. This method

maximises learners' potential, enabling them to gradually internalise and independently apply DH concepts in increasingly sophisticated ways.

2.7 ZONE OF POTENTIAL CONSTRUCTION

Steffe (1991) suggests that learners' cognitive structures evolve through the abstraction of actions and operations. In DH, this can be applied by presenting learners with tasks that are slightly beyond their current understanding but within their reach with proper guidance. For example, while learners may be familiar with basic statistical concepts, such as calculating the mean and median, teachers can introduce more complex tasks, such as interpreting multivariable data or designing surveys. These tasks challenge learners to stretch their cognitive abilities, encouraging them to engage with the material at a higher level, even before they fully master the foundational skills. By placing learners in this "zone of potential development", teachers can provide scaffolding that gradually reduces as learners' competence grows, ensuring that they are continuously operating within their ZPD.

According to Freund (1990), effective teaching within the ZPC requires a balance of high challenge and high support. In the DH classroom, this means creating opportunities for learners to engage in intellectually stimulating tasks that require them to apply and modify their existing knowledge. For instance, learners can be tasked with analysing real-world data sets, creating visualisations, and drawing conclusions from them. These tasks encourage learners to move beyond applying algorithms to actively engaging in higher-order thinking. The teacher provides targeted support when necessary, such as offering guidance on interpreting data trends or explaining advanced statistical techniques while encouraging learners to explore new ways of presenting data and solving problems independently. By focusing on the ZPC, teaching in DH builds on what learners already know. It fosters the development of their intellectual autonomy, preparing them for more advanced data analysis tasks in the future.

2.8 THREE CONCEPTS ZONES OF DEVELOPMENT

Taber (2018:8) highlights the significant role of the ZPD in educational discourse, a concept rooted in Vygotsky's work. Vygotsky emphasised that the ZPD is not a physical space but an "activity space" related to learners' behaviours, competencies, and potential challenges. He argued that assessing a learner's capabilities while working with an adult or more advanced peer helps determine what they can achieve with support, thus identifying the boundaries of their ZPD. According to Vygotsky (1978:86), understanding the ZPD provides valuable insights for teachers, enabling them to plan instruction that targets learners' potential for development. This assessment technique informs pedagogical strategies by distinguishing between learners' independent capabilities and what they could achieve with suitable support.

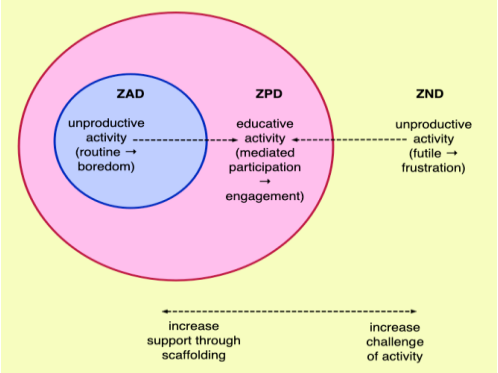

Figure 2.2: ***The most productive learning activities take place in the ZPD*** (Taber, 2020)

In Grade 10 Data Handling, Vygotsky's (1978) concept of the ZPD offers a robust framework for understanding and enhancing learners' cognitive growth. The ZPD is defined as the distance between what a learner can accomplish independently, while the Zone of Actual Development (ZAD) is what they can achieve with the guidance of a more knowledgeable other. This zone highlights the learning potential beyond a learner's current capabilities, but it remains accessible with support. In DH, a learner may already be able to calculate basic statistical measures such as the mean, median, or mode (ZAD), yet may struggle to interpret box-and-whisker plots or analyse real-world data for trends. These more complex tasks lie within the ZPD. By identifying such learning gaps, teachers can design instructional activities that are neither too easy nor too difficult, but rather appropriately challenging and support-driven, where meaningful learning is most likely to occur.

Applying the ZPD in DH requires the use of purposeful scaffolding strategies that gradually shift responsibility from the teacher to the learner. For instance, when learners cannot interpret a multi variable graph independently, teachers can provide structured assistance, such as modelling interpretation steps, prompting guided questions, or encouraging small-group collaboration, until learners gain the confidence and ability to perform the task independently. This process fosters internalisation of new knowledge through social interaction and guided practice, a central tenet of Vygotsky's theory. Importantly, the ZPD is not static; as learners develop, the boundaries of their ZPD shift, allowing for increasingly complex levels of engagement. By continuously assessing and targeting instruction within each learner's evolving ZPD, teachers can effectively bridge the gap between current understanding and potential competence in data handling, ultimately cultivating independent, critical thinkers capable of navigating real-world statistical challenges.

2.9 SCAFFOLDING

In the Grade 10 DH context, scaffolding plays a crucial role in helping learners who struggle with DH concepts to master them. As Bruner (1996) describes, scaffolding involves providing support that enables learners to accomplish tasks beyond their independent abilities. In this instance, peers or more capable learners can assist struggling learners by guiding them through the steps involved in calculating DH, breaking down each part of the process into manageable components. For example, a peer who understands how to find quartiles can help the struggling learner identify the correct positions in a data set and explain how to calculate each value, offering support at each stage until the learner can perform the task independently. The peer does not simplify the task but provides graduated interventions, ensuring the learner comprehends the process while avoiding frustration with the complexity of the concept.

Similarly, when drawing box-and-whisker plots, scaffolding is essential in helping learners grasp the relationship between the five-number summary and the graphical representation. Learners often struggle to translate numerical data into a visual plot, but peers can demonstrate how to do so on a number line with a drawn box and whisker plot through scaffolding. They can guide the learner in constructing a box and whisker plot, ensuring that the learner understands the significance of each component and how to plot the data accurately. As the peer provides this support, the learner's confidence increases, enabling them to apply these steps independently in future tasks. This peer-assisted learning environment fosters a deeper understanding of the DH concepts. It encourages collaboration, where learners assist one another in bridging the gap between their existing knowledge and their potential understanding (Vygotsky, 1978). This way, scaffolding allows learners to work within their ZPD and achieve greater autonomy in their DH skills.

2.9.1 What Is Instructional Scaffolding

Vygotsky's (1978) concept of the ZPD circles provides a foundational lens for understanding how learners progress from dependence to independence through guided support. As illustrated in Figure 2.1, adapted from McLeod (2018), the ZPD comprises tasks that a learner can accomplish alone, with help, and those that are currently beyond their reach. Instructional scaffolding plays a crucial role in bridging these zones by offering temporary, targeted support (Sarikas, 2020). In Grade 10 Data Handling, such scaffolding enables learners to master complex concepts through peer and teacher assistance. This framework promotes a more deeper understanding, collaboration, and independent learning, aligning with constructivist principles.

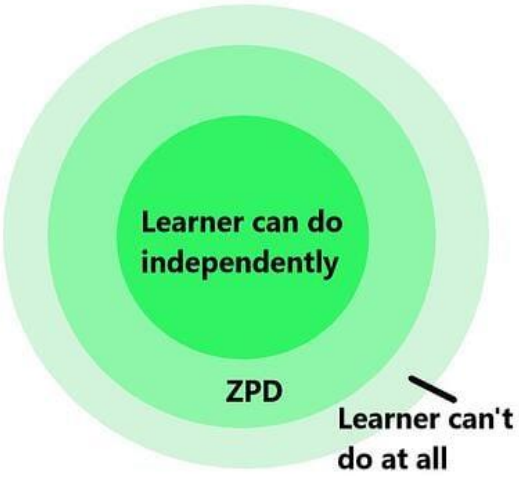

Figure 2.3: ***The ZPD Circles*** (McLeod, 2018)

In Figure 2.3, the diagram illustrates the core components of Vygotsky's ZPD through three concentric circles. The innermost circle represents tasks that learners can perform independently within their ZPD. The middle circle indicates tasks that learners can accomplish with guidance within their ZPD, while the outermost circle reflects tasks beyond the learner's ability, even with support. This visual framework helps teachers identify and structure appropriately challenging learning experiences, ensuring learners operate within their ZPD, the optimal zone for growth.

DH instructional scaffolding provides temporary support to help learners achieve tasks that exceed their independent abilities and is particularly effective in teaching complex statistical concepts (Sarikas, 2020). Vygotsky's theory posits that learners can achieve higher levels of understanding when supported by a more knowledgeable other, such as a teacher or peer. This could involve peer-to-peer assistance where a more competent learner supports a struggling peer in calculating a five-number summary (Min, Q1, Q2, Q3, Max) or constructing a box-and-whisker plot. Rather than providing direct answers, the advanced learner guides the process through questioning and demonstration.

This approach aligns with the principles of scaffolding by offering enough guidance to support success while requiring the learner to engage cognitively with the material. As learners progress, the support is gradually withdrawn, allowing them to transition from assisted to independent PS. In DH, learners move from basic data handling tasks to more sophisticated analysis and interpretation. Ultimately, this strategy promotes more profound understanding, engagement, and confidence, thereby reinforcing Vygotsky's belief in the social nature of learning and the transformative potential of guided interaction within the ZPD.

2.9.2 Assimilation and Accommodation

Piaget's concepts of Assimilation and Accommodation are foundational in understanding how learners process new information and integrate it into their existing knowledge frameworks (Schunk, 2021). Assimilation refers to how learners apply previously acquired concepts to new settings, integrating new knowledge into their existing cognitive structures, a process that has been widely discussed in educational psychology (Sweller, 2020). For instance, a Grade 10 learner may apply previously learned mathematical concepts, such as basic arithmetic, to understand the Five-number Summary in DH, even if the context or method is new, as emphasised in recent studies on cognitive development in secondary education (Gordon & McDermott, 2020). This process enables learners to deepen their understanding without requiring a significant restructuring of their cognitive frameworks, a principle first articulated by Piaget (Fitzgerald, 2021).

On the other hand, accommodation involves a more profound restructuring of a learner's existing knowledge to incorporate new information that does not fit neatly into their current understanding (Johnson & Taylor, 2022). In DH, this could mean that a learner, encountering a more complex concept such as Box and Whisker Plots, must adjust their thinking and approach to statistical data representation, as indicated by studies on cognitive restructuring in mathematical education (Williams & Patel, 2023). Accommodation, as a key cognitive process, enables learners to adapt their thinking to more sophisticated scenarios, as highlighted in recent discussions on constructivist learning theory (Zhang & Chen, 2024). Teachers play a crucial role in facilitating this transition by scaffolding learners through assimilation and accommodation, providing targeted support that ensures learners understand and can independently apply concepts in real-world scenarios (Walker et al., 2021). By successfully navigating these processes, learners move beyond basic knowledge to apply DH concepts in diverse, real-world contexts, thereby developing critical thinking and PS abilities (Lee & Hu, 2023).

2.10 CHAPTER SUMMARY

This chapter explored Vygotsky's Social Constructivist Theory, focusing on the ZPD and the ZPC, which emphasised the role of social interaction in learning. The ZPD comprised three key elements: the learner, the expert, and the task, with scaffolding identified as a critical factor in supporting cognitive development. The chapter also discussed Piaget's concepts of assimilation and accommodation, illustrating how learners integrated new knowledge into their existing cognitive structures. Additionally, it examined George Pólya's Problem-Solving (PS) strategy, which consisted of four phases: understanding the problem, devising a plan, executing the plan, and evaluating the solution. By integrating these theoretical perspectives,

the chapter highlighted the benefits of collaborative group work in Mathematics within DH, demonstrating how peer supported, socially mediated learning experiences enhanced learners' problem-solving abilities and conceptual understanding.

Chapter Three reviewed the literature on instructional strategies and cognitive development in DH education. It explored scaffolding in mathematical and problem-solving contexts, emphasising the benefits learners gain from guidance and peer collaboration, aligned with Polya's and Vygotsky's frameworks. The chapter situates scaffolding and the ZPD within the Grade 10 DH curriculum, highlighting their practical applications in education.

CHAPTER THREE: LITERATURE REVIEW

3.1 INTRODUCTION

This chapter builds on the theoretical foundations from Chapter Two by reviewing key literature on instructional strategies and cognitive development for Grade 10 DH learners. It critically examines structured pedagogical approaches, such as scaffolding, peer collaboration, and guided discovery, and their role in fostering learner autonomy in mathematical problem-solving.

The chapter explores the synergy between Polya's four-step method and Vygotsky's ZPD, demonstrating how their integration enhances conceptual understanding, critical thinking, and problem-solving skills. It also analyses DH curriculum requirements, common learning barriers, and the importance of scaffolding in cognitive development. Potential challenges, such as over-scaffolding and contextual constraints in South African classrooms, are discussed, providing a balanced critique that informs later instructional strategies.

A key focus is the role of collaborative learning in boosting confidence, engagement, and conceptual mastery, aligning with Vygotsky's emphasis on social interaction within the ZPD. Research from South Africa, South Korea, Japan, and Canada highlights the effectiveness of peer teaching and guided discovery in improving mathematical competency. In South Africa, cooperative learning has particularly enhanced participation, achievement, and higher-order thinking skills.

3.2 LITERATURE REVIEW

A literature review is crucial for consolidating existing research and comprehending the current state of knowledge (Thomas & Harden, 2023). It enables researchers to locate relevant theories and methods while highlighting areas that require further investigation (McCombes, 2022). By examining established and emerging concepts, the literature review helps refine the research focus, determine the study's significance, and identify gaps in the field (Creswell & Creswell, 2018; Cortes et al., 2024). Additionally, it provides a systematic approach to integrating prior findings, ultimately justifying the need for new research (Booth et al., 2021; Gough et al., 2017; Grant & Booth, 2020).

Recent studies reinforce these perspectives, with Cooper (2020) highlighting the importance of identifying research gaps through comprehensive literature reviews to inform future inquiry. Similarly, Hart (2018) observed that a well conducted literature review is crucial in defining research questions and framing hypotheses. Emphasising current trends, Tranfield et al. (2021) assert that a literature review should not only survey existing knowledge but also

challenge assumptions to inspire innovative research approaches. Furthermore, according to Zhang (2022), integrating contemporary sources into the review process enhances the researcher's understanding of evolving practices and theories.

3.3 TEACHING STRATEGIES AND THEIR IMPORTANCE

Effective teaching strategies in Grade 10 DH are essential for ensuring learners can confidently and proficiently navigate complex mathematical concepts. According to Hattie (2020), employing a well-structured strategy in the classroom enhances learner engagement and performance by addressing individual learning needs. In particular, calculating the five-number summary in DH is a critical skill that necessitates a strategic approach to deepen learners' understanding. Stigler and Hiebert (2019) noted that clear instructional strategies enable learners to grasp the connections between these statistical measures and effectively analyse data sets. Moreover, implementing specific strategies for teaching these concepts promotes both procedural fluency and conceptual understanding, and a dual focus has been shown to enhance learner outcomes (Kilpatrick, Swafford & Findell, 2021). Using varied instructional methods also aids learners in identifying patterns and making meaningful interpretations of the data, a skill essential for success in real-world applications (Cheung & Slavin, 2019).

Furthermore, according to Pimm (2020), providing learners diverse PS strategies improves their ability to calculate the five-number summary. It enhances their critical thinking, enabling them to apply these concepts across different contexts. Thus, a strategic approach to teaching these core DH skills fosters deeper learning and improves academic achievement in Grade 10 mathematics. Moreover, teachers must cultivate an environment where learners are encouraged to experiment with various methods for solving problems, which will help them identify the strategies that work best for them (Pimm, 2020). In doing so, learners acquire the ability to perform calculations and develop critical thinking skills essential for addressing real-world problems (Stigler & Hiebert, 2019). In line with this, Hattie (2020) emphasises that teachers who utilise a diverse range of strategies can better meet the varied learning needs of their learners, thereby enhancing engagement and performance. Additionally, pedagogical approaches that focus on procedural fluency and conceptual understanding enable learners to make deeper connections between mathematical concepts, ultimately leading to improved academic outcomes (Kilpatrick, Swafford, & Findell, 2021). Hence, it is crucial for teachers to continuously reflect on and refine their strategies to support learners' long-term success in mathematics, particularly in DH.

The integration of technology and interactive tools has also been demonstrated to enhance the learning experience by providing dynamic resources for PS (Cheung & Slavin, 2019). By

employing diverse instructional methods, teachers can ensure that learners develop the necessary skills to confidently approach DH challenges, thereby maximising their potential for success (Smith & Stein, 2018). Consequently, effective teaching strategies, resource allocation, and continuous professional development are essential for improving learner achievement in DH and mathematics.

3.3.1 Teaching strategies

Research has examined the integration of Vygotsky's sociocultural theory in Collaborative Group Work within Grade 10 Mathematics classrooms. Liu and Zhang (2023) highlight the benefits of CGW, demonstrating that peer interactions enhance PS skills, particularly in complex tasks such as data analysis. The (ibid) suggests that CGW enables learners to expand their understanding beyond individual capabilities as they collaborate to solve data related tasks. In contrast, Pino and Díaz (2022) present a more nuanced perspective, suggesting that CGW's success in mathematics depends on group dynamics. They argue that differing skill levels within groups can lead to unequal contributions, with more knowledgeable learners dominating discussions, which can potentially hinder the participation of less confident learners. This imbalance can impact the effectiveness of CGW in addressing complex DH tasks, where equal engagement is crucial for success.

Smith and Wilson (2024) further explore CGW, emphasising the teacher's role in guiding and mediating the process. They argue that, although peer scaffolding can be beneficial, teachers must facilitate CGW to ensure learners operate within their ZPDs. Their study demonstrates that teacher involvement leads to more focused discussions and improved PS outcomes, particularly in the complex context of DH. This highlights the importance of structured guidance during CGW. Foster (2023) critiques the traditional Vygotskian approach in CGW, suggesting that peer scaffolding might be less effective when learners have comparable levels of understanding. In such situations, Foster advocates focusing on metacognitive strategies, where learners reflect on and evaluate their PS methods. The (ibid) contends this shift can foster more sustainable PS skills, even without a hierarchical peer structure, especially for tasks like DH.

Zhang and Yang (2024) introduce the importance of cultural context, suggesting that collaborative group work in multicultural classrooms offers a rich environment for diverse problem-solving (PS) strategies. Their study suggests that when aligned with Vygotskian principles, CGW enables learners to share and learn from diverse mathematical approaches, thereby enhancing both cognitive and social development. However, Hernández et al. (2023) caution that CGW may not always result in deep engagement with mathematical concepts, as learners might focus more on completing tasks than on understanding the underlying

principles, thereby limiting the long-term benefits of this collaborative approach for tasks such as dynamic assessment (DH).

3.4 APPLICATION OF PROBLEM-SOLVING STRATEGIES

Recent studies have thoroughly examined PS and Vygotsky's theoretical framework to understand their effects on learning and cognitive development. According to Lerman (2022), PS entails learners employing higher-order thinking strategies to tackle unfamiliar tasks. Engaging with complex problems is linked to cognitive development, with Vygotsky's concept of the ZPD providing valuable insights into how guided PS within a social context can enhance cognitive abilities (Lerman, 2022). Similarly, Ren (2021) argued that Vygotsky's theory emphasises the significance of social interaction in PS. By collaborating with more knowledgeable peers or teachers, learners can address problems beyond their current capabilities, underscoring the role of collaborative PS in cognitive growth.

Vygotsky's concept of scaffolding has been extensively examined in relation to problem-solving (PS). According to Jang et al. (2023), scaffolding is essential for learners to cultivate PS skills, as it offers necessary support that is gradually withdrawn as learners attain independence. The (ibid) contends that this interaction and guidance are particularly beneficial in mathematics, where abstract concepts demand high cognitive engagement. Similarly, DeLoache (2022) emphasises how Vygotsky's perspective on language development promotes PS, with language as a tool for externalising thought processes and structuring PS strategies. PS can be enhanced through explicit verbal reasoning, which aligns with Vygotsky's notion that thinking develops through social interaction (DeLoache, 2022).

Matusov (2020) critiques Vygotsky's emphasis on social context by examining how problem-solving in solitary conditions may lead to different cognitive processes. While collaborative problem-solving is beneficial, Matusov (2020) suggests that individual problem-solving offers an alternative cognitive trajectory, where self-regulation and independent thinking are crucial for deeper understanding. This aligns with Vygotsky's later recognition of the individual's role in the development of cognitive skills. Nevertheless, solitary problem-solving should still be viewed in the context of social interaction, as even independent problem solvers internalise tools from their environment, such as language and symbols, to tackle complex problems.

Lin and Zhu (2023) have demonstrated the efficacy of technology-enhanced problem-solving (PS) activities within the Vygotskian framework. The (ibid) found that digital tools and platforms can promote social interaction and provide dynamic scaffolding, enabling learners to collaborate more effectively as they tackle problems. This approach integrates technology into the ZPD, enhancing engagement and providing immediate feedback to create an interactive and adaptive learning environment. The study highlights the significance of merging

Vygotskian principles with contemporary educational technologies, suggesting that such integration fosters PS skills in real-world contexts. Belland et al. (2022) have extended Vygotsky's theory into mathematics classes, where collaborative problem-solving activities are crucial for helping learners navigate complex tasks. Belland et al. argue that problem-solving in the classroom requires not only individual knowledge but also the ability to communicate and collaborate effectively. The capacity to work with others in solving problems reflects Vygotsky's assertion that cognitive development is a social process where interaction facilitates deeper understanding. Through collaborative problem-solving in classrooms, learners internalise strategies and heuristics that extend beyond their initial capabilities, demonstrating the practical application of Vygotsky's theory in contemporary education.

Finally, recent research has strengthened the synergy between Vygotsky's socio-cultural theory and PS practices, demonstrating the critical role of social interaction, scaffolding, and language in enhancing cognitive development. Scholars have continued to investigate how collaborative PS in various contexts, such as mathematics, aligns with Vygotsky's concept of cognitive development within the ZPD. The growing body of literature highlights the significance of this theoretical framework in contemporary education, particularly in developing PS skills across various disciplines. As these studies suggest, incorporating Vygotskian principles into teaching practices has the potential to nurture critical thinking and PS abilities, which are essential for learners' success in both academic and real-world settings.

3.5 COLLABORATIVE PROBLEM-SOLVING

Collaborative problem-solving (CPS) has emerged as a crucial component in educational settings, linked to enhanced critical thinking, deeper understanding, and improved learning outcomes. Recent studies emphasise that the collective engagement of learners in problem-solving tasks provides an enriched learning experience where individual cognitive processes are expanded through peer interactions. According to Koriat et al. (2023), when learners collaborate to solve complex problems, they are exposed to diverse perspectives and refine their understanding by negotiating meanings with their peers. This aligns with social constructivist theories, which emphasise the importance of interaction in the learning process (Vygotsky, 2022). The (ibid) asserts that social interaction plays a pivotal role in cognitive development. These findings highlight the pivotal role of CPS in fostering collaborative learning environments that promote deeper cognitive engagement and knowledge construction.

The facilitation methods employed by teachers further enhance the effectiveness of CPS. Lang et al. (2024) demonstrate that teacher involvement in CPS activities significantly enriches the learning experience by providing structure and guidance. The authors argue that teachers

must intentionally foster a collaborative climate, offering support when necessary and allowing learners the space to take ownership of their learning. Effective facilitation involves guiding discussions, encouraging diverse perspectives, and ensuring that group members participate meaningfully in the task. Lehrer et al. (2024) support this concept, asserting that structured guidance during collaborative tasks enhances learners' ability to tackle complex problems, making collaboration more purposeful and productive. Thus, the role of teachers in guiding cooperation is important to ensure that the group dynamic is conducive to effective PS.

While the cognitive benefits of collaborative problem-solving (CPS) are well documented, the social outcomes of such practices have received increased attention in recent years. Muirhead and Burnett (2023) emphasise that CPS fosters essential interpersonal skills, including communication, conflict resolution, and empathy. They suggest that learners learn to navigate differing opinions and approaches through collaboration, fostering a greater sense of responsibility and teamwork. Moreover, this aspect of CPS is particularly significant in increasingly diverse classrooms, where learners from diverse cultural and social backgrounds collaborate to address common issues. The research furthermore emphasises that the social skills acquired through CPS are transferable to both professional and personal contexts, making collaborative problem-solving a vital strategy for developing well-rounded individuals equipped to confront the complexities of the modern world.

Another significant advantage of CPS is its potential to foster deeper engagement and motivation among learners. Vriend et al. (2024) highlight that learners exhibit higher levels of intrinsic motivation when they collaborate to solve problems than those who work individually. The collaborative nature of the task encourages learners to invest in the learning process, as they recognise the value of their contributions in a group setting. This sense of belonging and purpose within the learning community fosters a positive attitude towards the subject matter and can lead to improved academic outcomes. Additionally, Hwang et al. (2023) suggest that CPS motivates learners to persist in facing challenges as they draw strength and support from their peers. This motivation, reinforced by a collaborative environment, can significantly enhance learners' resilience and determination in overcoming academic hurdles.

Furthermore, collaborative problem-solving fosters the development of metacognitive skills, enabling learners to become more aware of their thinking processes and methods for tackling problems. McIntyre and Houghton (2024) revealed that engaging in CPS tasks encourages learners to reflect on their PS strategies, identifying strengths and weaknesses as they navigate complex challenges. By discussing their thought processes with peers, learners gain insight into alternative approaches and refine their strategy, resulting in a more flexible and adaptive mindset. This metacognitive awareness, nurtured through collaborative problem-

solving, underpins learners' long-term academic success by promoting a deeper understanding of tackling problems and learning tasks more effectively.

Collaborative Problem-solving (CPS) aligns with the growing demand for educational practices that prepare learners for the workforce, where teamwork and PS are essential. Rojas and Kim (2023) emphasise that employers increasingly value teamwork skills, making CPS an integral part of modern education. Engaging in CPS activities enables learners to develop academic skills while also refining critical teamwork, communication, and leadership abilities essential for success in professional environments (O'Neil et al., 2021; Liew et al., 2022). Moreover, CPS bridges the gap between theoretical knowledge and practical application, equipping learners to tackle real-world challenges in collaborative settings (Norris et al., 2023; Zhang & Li, 2024). This connection between CPS and employability highlights its broader societal value, reinforcing its importance in contemporary educational curricula. Recent studies also emphasise the importance of teacher facilitation in ensuring structured and meaningful CPS activities, which contribute to learners' cognitive, social, and metacognitive development, thereby preparing them for future careers (Dede et al., 2022; Williams & Smith, 2023). CPS represents a transformative approach that equips learners with the necessary tools to thrive both academically and professionally.

3.6 LEARNER'S PERFORMANCE IN DH

The diagnostic report on learners' performance regarding the concepts of DH when applying PS approaches and Vygotsky's sociocultural theory within Collaborative Group Work reveals notable improvements in learners' understanding and application of DH. Harris (2020) found that learners' ability to interpret and analyse data improves significantly when they engage in collaborative PS activities. Similarly, the DBE (2021) emphasised that peer interactions in CGW enable learners to tackle complex DH problems together, fostering a deeper comprehension of the subject. Vygotsky's (1978) theory supports this, as it emphasises the role of social interactions in cognitive development, which is evident when learners benefit from collaborative group work.

Furthermore, implementing PS techniques within CGW settings has enhanced learners' critical thinking and analytical skills, particularly in DH. Smith and Martinez (2022) found that learners involved in PS tasks within CGW environments demonstrated a better understanding of DH concepts than those who worked alone. The DBE (2022) also emphasised the importance of group work, noting that learners who engage in peer-assisted PS display higher levels of conceptual understanding in DH.

Additionally, scaffolding plays a vital role in learners' performance in DH when implemented within collaborative group work (Vygotsky, 1978). Roberts and Davis (2023) found that

learners who received scaffolded guidance from teachers or more knowledgeable peers within CGW were better equipped to tackle more challenging DH problems. This guided learning process, where learners gradually take on more complex tasks, reflects the ZPD and enables learners to achieve higher cognitive levels. DBE (2023) also supports the utilisation of scaffolding in the classroom, arguing that when learners are provided with appropriate support during group work, they are better prepared to understand and independently apply DH concepts over time.

The diagnostic report highlights the effectiveness of integrating PS strategies with Vygotsky's sociocultural theory in CGW to enhance learners' performance in DH. Thompson (2024) emphasises that the collaborative and scaffolded nature of CGW, when aligned with Vygotskian principles, leads to improved PS and DH skills. The DBE (2024) agrees, highlighting that learners who participate in such interactive and supportive learning environments tend to excel compared to those in traditional, isolated learning settings. This body of research collectively indicates that PS within CGW, bolstered by Vygotsky's theory, significantly enhances learners' ability to manage data-related tasks and promotes deeper cognitive engagement with DH concepts.

3.7 STRATEGIES TO TEACH DATA HANDLING

DH is a crucial area in mathematics that can be challenging for teachers, particularly when they lack effective teaching strategies. While mathematics is often regarded as the "queen of all sciences," some teachers find it challenging to identify methods that enable learners to excel in DH. According to Das (2019), exploring unconventional strategies can help to overcome these challenges. McCallum (2018) argues that before learners can comprehend new DH concepts, they must first understand the existing ones. Teachers frequently employ techniques such as number talks to help learners develop their numerical reasoning (Parrish, 2011). A social constructivist approach, drawing on the work of Piaget (1968) and Vygotsky (1978), encourages active learning, where learners build their understanding through interactions with peers and more experienced individuals. Incorporating George Polya's four-step PS strategy further enhances this approach, promoting a deeper engagement with the material.

Social constructivism is a significant philosophical perspective in the teaching and learning of DH. Teachers who grasp this approach tailor their strategies to align with the learners' current levels of understanding (Udemy Editor, 2019). Piaget's theory of cognitive conflict and Vygotsky's zone of proximal development highlight the necessity of peer and expert interactions in facilitating learning. Within the framework of Cognitive Growth and Wisdom (CGW), Vygotsky's scaffolding techniques support learners by providing guidance as they

encounter complex problems, ultimately fostering greater independence as their understanding deepens. Moreover, Polya's approach emphasises collaborative problem-solving, enabling learners to work collectively, share their thought processes, and enhance their comprehension. Hassan (2021) also notes that classrooms are diverse, necessitating effective teaching strategies that are adaptable to meet the unique needs of each learner.

The role of the teacher is crucial in implementing effective teaching strategies. Teachers' beliefs, attitudes, and practices have a significant impact on learners' motivation and achievement (IPL, 2021). The challenge lies in identifying methods that actively engage learners and make learning more accessible and practical. Effective teaching of DH requires teachers to adjust their strategies to accommodate diverse learning styles, whether through lectures, collaborative group work, or the use of technology (Barkley, 2021; Jonassen, 2019). By integrating Polya's systematic problem-solving process, teachers can help learners break down complex DH tasks, enabling them to engage with and solve problems step-by-step, thereby strengthening their understanding (Schunk, 2020; Pólya, 2023). This approach fosters deeper engagement and equips learners with critical PS skills necessary for academic success and future challenges (Sweller, 2020).

Teaching strategies for DH must also be inclusive, ensuring that all learners, including those with disabilities, can access and engage with the curriculum. Armstrong (2020) emphasises the importance of adapting teaching strategies to accommodate diverse learners, thereby ensuring equal participation for learners with varying abilities. Assessing learners' learning needs and developing targeted strategies to meet those needs is crucial for ensuring success in DH, as the subject relies heavily on logical thinking and PS skills. By combining various strategies and regularly assessing learner progress, teachers can ensure that all learners can succeed in mastering DH concepts. Integrating Vygotsky's ZPD and Polya's PS approach within the CGW framework provides a flexible and structured method to offer learners the necessary support to achieve mastery and become independent problem solvers.

3.8 GLOBAL TRENDS AND TEACHING APPROACHES

In recent years, global education trends have increasingly focused on enhancing PS skills in DH for Grade 10 learners, driven by the growing importance of data literacy. As Angrist and Pischke (2023) noted, educational systems worldwide are incorporating data handling more prominently into curricula, with countries like Singapore and Finland emphasising problem-solving and collaborative group work. Chen et al. (2024) highlight how these countries successfully implement problem-solving strategies, where learners work in groups to solve data related problems, thereby enhancing their ability to analyse and apply data.

Lee and Zhang (2024) highlight the effectiveness of applying Vygotsky's principles in CGW settings to teach Grade 10 learners how to solve DH problems collaboratively. This method positions the teacher as a guide, providing appropriate challenges and scaffolding based on learners' abilities within their ZPD. Countries with strong STEM educational standards, such as South Korea and Japan, have successfully utilised this approach, enabling learners to benefit from group work in which they share strategies, discuss methods, and solve data problems together, thereby deepening their understanding of complex DH (Kim & Johnson, 2023).

International comparisons demonstrate that CGW approaches rooted in Vygotskian theory encourage more active learning and higher achievement among Grade 10 learners (Naughton & Ma, 2024). In Canada, for instance, learners are taught to approach data analysis as a PS process, with CGW integral to their education. Through practical activities like data collection, interpretation, and visualisation, learners engage in collaborative work that promotes critical thinking. Vygotsky's scaffolding techniques enable teachers to assist learners through complex tasks, providing support as necessary and gradually withdrawing assistance as learners enhance their proficiency. This approach enhances learners' technical skills and fosters collaboration and communication abilities, preparing them for future academic and professional challenges.

Wilson and Foster (2023) emphasise the role of digital tools in supporting PS within DH, reflecting the global trend toward technology enhanced learning. These platforms facilitate real-time collaboration, enabling learners to work together on data related challenges, even from a distance. By incorporating Vygotskian scaffolding, these digital tools provide feedback and hints, guiding learners through the PS process. Gray and Ball (2024) further indicate that such platforms assist with specific PS tasks and help learners develop critical digital literacy skills, essential for navigating today's data-driven environment. Global trends in DH education for Grade 10 learners demonstrate that PS approaches within CGW frameworks, informed by Vygotsky's theory, significantly enhance learners' ability to engage with complex data tasks. Technology integration and a focus on collaborative learning have proven highly effective in developing learners' data literacy. Robertson and Clarke (2023) report that countries prioritising this approach have witnessed improvements in critical thinking, PS, and teamwork skills, equipping learners with the competencies necessary to thrive in a data-driven world.

3.9 TEACHER TRAINING AND PROFESSIONAL DEVELOPMENT

The practical implementation of PS strategies in DH for Grade 10 learners necessitates specialised teacher training. Li and Zhou (2023) emphasise that professional development must concentrate on pedagogical approaches, including Vygotsky's sociocultural theory within

CGW frameworks. Teachers must learn how to scaffold learners' learning within the ZPD to assist them in tackling complex DH tasks. Harrison and Wright (2024) further emphasise the importance of training programmes that teach Vygotskian scaffolding and PS techniques, enabling teachers to effectively guide learners through data challenges.

Ongoing professional development is crucial for keeping teachers up-to-date on the latest educational practices and tools that enhance DH instruction. Gray and Ball (2024) report that professional development programmes increasingly focus on the use of digital tools, such as Google Sheets or Tableau, to support PS in DH. These tools facilitate real-time data analysis and learner collaboration, which is important for implementing Vygotskian scaffolding in CGW settings. Zhang and Liu (2024) assert that teachers trained in these tools are better equipped to engage learners in PS activities and promote deeper learning in DH. Consequently, such tools enable teachers to monitor learner progress and provide timely, targeted support.

Professional development programmes also promote teacher collaboration, essential for refining PS strategies in the classroom. Martínez and Perez (2023) emphasise that professional learning communities (PLCs) offer teachers opportunities to share strategies for teaching DH through PS. Collaboration enables teachers to exchange insights on the best ways to support learners using Vygotskian scaffolding and CGW techniques. Black and Thomas (2024) demonstrate that such collaboration enhances instructional practices and helps teachers build a shared understanding of how to teach complex topics, such as DH. The successful integration of PLCs in countries such as Canada and Australia has enabled teachers to create collaborative PS environments that effectively support learners.

Integrating Vygotsky’s theory into teacher training enhances teachers' ability to support diverse learners in Grade 10 classrooms. Davis and Wallace (2024) suggest that training programmes focused on differentiated instruction within the CGW framework help teachers address the varied needs of learners in DH. By understanding each learner’s ZPD, teachers can effectively scaffold their learning, ensuring all learners can solve complex data problems. Li and Zhou (2023) note that professional development emphasising personalised support and PS strategies promotes inclusive learning environments. This is particularly advantageous in heterogeneous classrooms where learners possess differing levels of prior knowledge and skills in DH. Harrison and Wright (2024) conclude that ongoing teacher training is essential to ensure teachers are equipped to provide the necessary support for learners to engage deeply with DH content and collaborate on problem-solving.

3.10 REFORM IN TEACHING AND LEARNING STATISTICS

Reforming teaching and learning in DH is becoming increasingly essential in the modern educational landscape, particularly given the rapidly changing world. As Cobbs (1992)

emphasised, enhancing statistics education relies on aligning teaching practices with robust theoretical and empirical research. By ensuring that teaching methods are grounded in these foundational studies, teachers can be equipped with practical strategies and clear guidelines to enhance the mathematical knowledge required for primary education teachers to impart DH concepts effectively. Today, as we navigate an era of data-driven decision making, it is crucial for learners to develop the skills to interpret and analyse data accurately. Vásquez and Alsina (2021) argue that this ability is indispensable for success in an increasingly complex world.

Furthermore, visual teaching strategies have been recognised as pivotal in facilitating the comprehension of DH. Nghidinwa (2021) emphasises that visual models play a critical role in helping learners form lasting mental images that simplify abstract statistical concepts. These models enhance conceptual understanding and improve PS capabilities by providing concrete representations of otherwise abstract ideas. Recent research suggests that this visual approach is particularly effective in promoting long-term retention and fostering a deeper understanding of statistical relationships, aligning with findings from contemporary studies on visual learning (Liu & Chen, 2022). By making abstract DH concepts more tangible, learners are better prepared to engage with and tackle complex problems.

Differentiated instruction in DH classrooms is also essential. Marumo (2017) emphasised the importance of adapting teaching strategies to address learners' varied learning needs. This is particularly vital in subjects like DH, where learners may differ significantly in their prior knowledge and capabilities. Teachers can foster an inclusive classroom environment that supports all learners in their learning journey by employing strategies such as grouping learners based on their learning needs and providing varying levels of challenge. As recent studies indicate (Zhang et al., 2023), differentiated instruction helps bridge learning gaps, promotes active participation, and nurtures a deeper engagement with the content. This approach, which modifies teaching methods, assessments, and resources to cater to individual differences, ensures that every learner receives the appropriate level of challenge and support. Ultimately, it cultivates a learning environment that not only aids learners in mastering DH concepts but also prepares them for success in a data-rich world.

3.11 DEFICIENCY IN PRIOR KNOWLEDGE

A significant challenge in teaching DH is the deficiency in teachers' foundational knowledge of the subject matter. Teachers often possess limited or insufficient understanding of the core principles of DH, which directly impacts their ability to effectively convey the material to learners (Ball, 2018; Darling-Hammond, 2021). According to Cumming et al. (2022), teachers' misconceptions and gaps in prior knowledge can lead to teaching approaches that are either too simplistic or overly complex, resulting in confusion among learners. This issue highlights

the need for ongoing professional development and more comprehensive teacher education programmes to ensure that teachers possess the content knowledge and pedagogical skills specific to DH.

Moreover, the impact of prior knowledge on teaching approaches cannot be understated. Teachers' foundational understanding of DH shapes their instructional strategies, curriculum delivery, and ability to assess learners' grasp of the content (Schmidt, 2020). According to Watson and Jones (2023), teachers with inadequate prior knowledge often rely on traditional methods that fail to promote deeper learning or critical thinking among learners. Bridging the gap in prior knowledge is crucial to facilitating more effective teaching and learning experiences in DH classrooms, and it demands targeted professional development that focuses on strengthening content knowledge and pedagogical strategies.

3.12 TEACHING APPROACHES IN DH

Teachers' methods and strategies to deliver DH content play a crucial role in shaping learners' understanding of the subject. Recent research suggests that active learning strategies, such as collaborative PS and inquiry-based learning, significantly enhance learners' ability to engage with DH concepts (Barkley, 2021). These approaches promote deeper cognitive processing and encourage learners to apply their knowledge in real-world contexts (Hattie, 2019). As Anderson and Krathwohl (2021) noted, teachers who employ learner-centred teaching methods, such as project-based learning or flipped classrooms, create an environment where learners actively participate in their education, fostering a better understanding of DH concepts.

Pedagogical techniques for delivering DH content must be diverse and adaptable to accommodate the varying needs of learners. Practical teaching approaches incorporate technology, multimedia resources, and visual aids to clarify complex DH topics and enhance learner engagement (Jonassen, 2019). Recent studies by Garrison et al. (2020) also emphasise the importance of formative assessment and feedback in guiding learners' progress. By utilising these varied instructional strategies, teachers can address different learning styles, providing opportunities for learners to explore DH concepts that resonate with their individual learning preferences, thereby improving overall learning outcomes.

3.13 CHALLENGES IN TEACHING DH

Teachers face numerous difficulties when delivering DH lessons, with one of the most significant challenges being the complexity of the subject matter itself. DH involves abstract concepts such as probability, statistics, and data analysis, which can be difficult for teachers and learners to fully grasp (McMillan, 2022). According to Hardy et al. (2023), this complexity

is compounded by the fact that many teachers may lack sufficient training in statistical methods or data literacy, affecting their ability to teach these concepts effectively. Furthermore, teachers often struggle to convey the relevance of DH content to real-life applications, leading to a lack of learner motivation and engagement.

Constraints such as limited resources, inadequate technology, and overcrowded classrooms further exacerbate the challenges of teaching DH. According to Jones and Schmidt (2021), teachers in resource poor environments face challenges in utilising tools such as data analysis software or online databases, which can hinder effective lesson delivery. Additionally, curriculum constraints and rigid assessment frameworks often limit teachers' flexibility in adapting lessons to better suit learners' needs and interests. These constraints necessitate innovative solutions, including the development of low cost teaching materials and the integration of online resources that can enhance the learning experience for both teachers and learners.

3.14 ENHANCING TEACHING STRATEGIES

Enhancing instructional practices in DH requires implementing evidence-based teaching methods that promote learner engagement and learning. Recent research suggests that inquiry-based learning, where learners actively explore data sets and draw their own conclusions, is particularly effective in developing critical thinking and problem-solving skills (Gibson et al., 2022). Furthermore, incorporating collaborative learning activities enables learners to work together to analyse and interpret data, fostering cognitive and social learning (Cortese & Kember, 2020). These teaching strategies support the development of learners' DH skills and promote essential skills such as teamwork and communication, which are critical in today's data-driven world.

Professional development and support mechanisms for teachers are key factors in enhancing teaching strategies in DH. Ongoing training programmes that focus on integrating technology, data analysis tools, and effective pedagogical techniques can help teachers refine their teaching practices (Lee, 2021). According to Zhao et al. (2023), mentorship programmes and collaborative professional learning communities are critical in improving teacher effectiveness. By providing teachers with opportunities for continuous learning and peer support, educational institutions can foster an environment where teaching strategies evolve in response to learners' changing needs and the evolving field of DH.

3.15 CHAPTER SUMMARY

This chapter presented a comprehensive review of the literature related to instructional strategies, cognitive development, and pedagogical challenges in the teaching of DH at the

Grade 10 level, with a focus on the Bojanala district of Rustenburg. Drawing on both international and local studies, the review highlighted the importance of scaffolding, constructivist approaches, and cognitive strategies, such as assimilation and accommodation, in supporting learners' mathematical problem-solving abilities. The findings emphasised that effective teaching practices rooted in Vygotsky's Social Constructivism and Polya's four-step PS framework are essential for promoting learner autonomy and conceptual understanding in DH. The literature also highlights that inadequate instructional methods, particularly in under resourced educational settings, significantly contribute to poor performance in DH. The next chapter, Chapter Four, outlines the research methodology employed in this study. It details the research design, data collection techniques, sampling strategies, and data analysis procedures used to investigate the teaching and learning of DH in the Bojanala district.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 INTRODUCTION

Following a comprehensive review of the literature, this chapter outlines the research methodology that underpins the study. It provides a detailed exposition of the research design, data collection techniques, sampling strategies, and data analysis procedures employed to investigate the teaching and learning of DH in the Bojanala district. By outlining these methodological considerations, the chapter establishes a framework to ensure the validity, reliability, and rigor of the findings of the study.

Research methodology is broadly recognised as a foundational blueprint that informs the overall conduct of a study. It encompasses the underlying philosophical perspectives, the chosen research design, methods of data collection, and approaches to data analysis. Creswell and Creswell (2018) describe it as integrating worldview assumptions, methodological strategies, and the specific procedures employed throughout the research process, whether using qualitative, quantitative, or mixed methods. Similarly, Saunders, Lewis, and Thornhill (2019) view methodology as the conceptual rationale guiding research activities, stressing that these choices must align with the study's objectives and research questions. Cohen, Manion, and Morrison (2018) argue that methodology serves as the link between theoretical principles and practical application, thereby helping to ensure the reliability and validity of the research. Likewise, Silverman (2021) suggests that methodology is more than a procedural outline; it is a reflective process that influences the integrity of the study and how findings are interpreted. The aim of the study was to investigate the measures teachers should implement when instructing DH in Grade 10.

4.1.1 The Research Question

What teaching strategies are employed by Grade 10 Mathematics teachers to teach Data Handling in two selected schools within the Bojanala District?

4.1.2 Sub-Questions

RQ1: How do teachers teach Data Handling to Grade 10 learners?
RQ2: What challenges do teachers encounter when teaching Data Handling practices?
RQ3: What strategies can teachers employ in Grade 10 to effectively teach Data Handling?

The hypotheses for the study were formulated as follows:

H_0: The application of Strategies does not affect the performance of DH Grade 10 learners.

H_1: The application of Strategies does affect the performance of the DH Grade 10 learners.

4.2 RESEARCH PARADIGM

A research paradigm is a comprehensive belief system or worldview that guides the researcher in philosophical and methodological approaches to inquiry, shaping how reality is understood and investigated (Creswell & Creswell, 2018). The major paradigms commonly identified in educational and social research include positivism, interpretivism, critical theory, and constructivism. Positivism assumes that reality is objective and can be measured through empirical observation and scientific methods, favouring quantitative approaches (Cohen, Manion & Morrison, 2018); however, this perspective is irrelevant to my study because it neglects the subjective meaning and contextual understanding. Interpretivism emphasises understanding human experiences through context and social interaction (Merriam & Tisdell, 2016), but it lacks the transformative intent that my study demands. Critical theory, which focuses on challenging and changing social structures through empowerment and critique (Kincheloe & McLaren, 2011), also extends beyond the immediate aims of my research, as it does not directly engage in macro level societal change. Pragmatism offers methodological flexibility, focusing on solving practical problems through a combination of quantitative and qualitative methods (Creswell & Plano Clark, 2017). However, since the study prioritised depth over breadth and aimed to understand personal meaning-making, it was not the best fit. Therefore, constructivism was the most appropriate paradigm for the research.

Constructivism posits that individuals construct knowledge through their experiences and social interactions (Lincoln & Guba, 1985). In the study, constructivism was applied by collecting qualitative data through semi-structured interviews, allowing participants to express how they interpret and make sense of their lived experiences. This paradigm enabled the researcher to explore participants' subjective perspectives within their cultural and social contexts, making the research more authentic and nuanced (Guba & Lincoln, 1994). The advantage of using constructivism lies in its ability to provide rich, contextual insights into how individuals understand their reality, which aligns with the research objectives focused on exploring depth rather than generalizability (Patton, 2015). Thus, constructivism not only grounded my methodology but also enhanced the credibility and relevance of the findings.

Comprehending research paradigms is vital as they shape the beliefs and assumptions that guide scientific inquiry (Park et al., 2020). A paradigm defines the researcher's view of reality and knowledge, influencing all aspects of the research process (Creswell & Creswell, 2018; Guba, 1990). These are framed by four key elements: ontology, epistemology, methodology, and methods (Coe et al., 2017; see Figure 4.1). Understanding these components helps researchers justify their choices and ensure the relevance and ethical integrity of their work (Mertens, 2015; Creswell & Poth, 2018). See Figure 4.1.

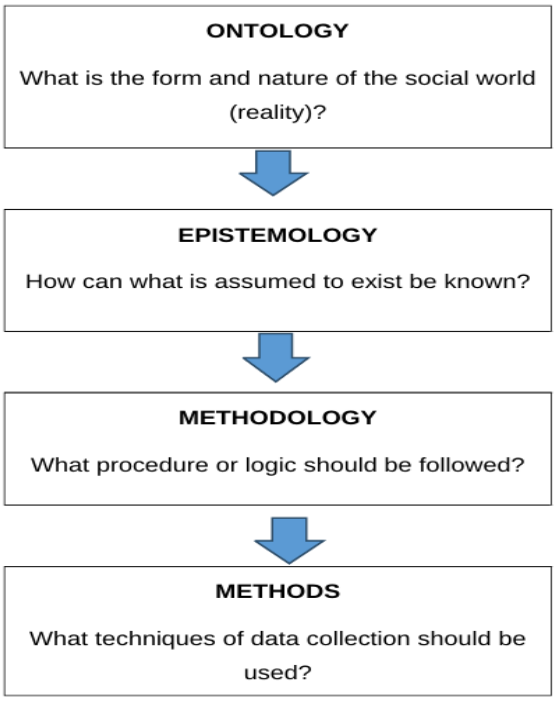

Figure 4.1: ***The interconnection among ontology, epistemology, methodology, and methods*** (Coe et al., 2017)

This study employed the ontology paradigm. The adoption of ontology is endorsed by Wand and Weber (1993:220), who characterise it as the philosophical discipline focused on delineating the nature and organisation of reality. Ontology examines the essence of reality and the extent to which it is comprehensible. This method highlights the belief that reality exists independently of human perceptions and can be analysed to understand its fundamental structure. Furthermore, ontology helps researchers identify which aspects of reality warrant exploration and how they can be depicted within the framework of the study (Mingers, 2001). This study investigated the fundamental truths and assumptions about the world from an ontological perspective, providing deeper insights into the research issue. The study employed a constructivist ontological framework, which posited that knowledge of teaching practices in DH was constructed through social interactions and the personal experiences of learners and teachers. This perspective emphasised the significance of understanding participants' lived experiences within their educational context (Hacking, 2015).

Moreover, Ontology is the study of the nature of reality and what can be known. It is a foundational element within a broader research paradigm, not a paradigm in itself. A research paradigm is a comprehensive framework that encompasses four key components: ontology (the nature of reality), epistemology (the nature of knowledge), methodology (the research process), and axiology (the role of values in research). These components collectively shape

a researcher's worldview and influence the design and conduct of research. Pretorius (2024) notes that understanding these elements is crucial for developing coherent and philosophically grounded research designs, particularly in the humanities and social sciences. Similarly, Lincoln and Guba (1985) emphasise that a paradigm comprises these four elements, which guide researchers in their inquiry. Therefore, while ontology addresses questions about the nature of reality, it operates within the context of a research paradigm that encompasses epistemology, methodology, and axiology, providing a comprehensive research approach.

The constructivist approach emphasises that knowledge is not passively received but actively constructed by individuals as they interact with their environment and one another. By focusing on this perspective, the study aims to capture the dynamic and context-specific nature of teaching and learning, acknowledging that each participant's interpretation of their experiences shapes their understanding of teaching strategies. The rationale for adopting constructivism in this study is grounded in its ability to explore how knowledge is collaboratively built through these interactions, offering deeper insights into how individual and collective experiences influence educational practices and learning outcomes. This approach also encourages examining how different perspectives contribute to the co-construction of knowledge, fostering a richer understanding of teaching strategies within the DH curriculum.

Epistemology was employed in this study, which concerns the nature and scope of knowledge, including the acquisition of knowledge. A pragmatic epistemology could be applicable, where knowledge is viewed as dynamic and contingent on teaching and learning context (Creswell & Poth, 2018). This approach focuses on practical solutions to educational challenges. It recognises that knowledge can be derived from various sources, including quantitative data (pre- and post-tests) and qualitative insights (interviews and observations).

The methodology employed in this study outlined the systematic processes used to conduct the research. A structured approach was adopted to ensure the reliability and validity of the findings. This methodological framework provided a clear and reproducible pathway for achieving the research objectives. The researcher employed a mixed-methods technique, which entails an explanatory sequential design. Quantitative data were first collected through pre- and post-tests to assess the efficacy of teaching tactics, followed by qualitative data collection via semi-structured interviews and classroom observations to gain a deeper understanding of participants' experiences and viewpoints. This amalgamation facilitates a thorough comprehension of the influence of pedagogical practices on learning (Tashakkori & Teddlie, 2010).

4.2.1 Pragmatism

This study utilises pragmatism, as the researcher acknowledges the possibility of multiple

realities, which is essential for addressing the research challenge (Creswell & Creswell, 2018a:8). Grey et al. (2017:489) emphasise that researchers are moving away from the idea of a singular dominant paradigm or research strategy, instead arguing that knowledge can be acquired through the utilisation of all available methodologies. In contrast to post-positivism, which prioritises an objective world examined through empirical evidence, and interpretivism, which focuses on subjective experiences, pragmatism allows for the integration of both objective and subjective methodologies. This flexibility makes pragmatism particularly suitable for exploring complex educational issues, where quantifiable facts and individual perspectives enrich understanding of the research topic and social constructs. Furthermore, pragmatism merges quantitative and qualitative methodologies, providing a pragmatic framework for addressing real-world challenges and aligning smoothly with an explanatory mixed-method design by encouraging diverse methods to tackle the research issue.

By combining pre- and post-tests (quantitative) with interviews and observations (qualitative) in DH, the researcher can examine the measurable outcomes of teaching strategies and the contextual factors that influence these outcomes in DH results. Pragmatism values the practical implications of research, focusing on what works in specific contexts rather than adhering to a single rigid methodology or worldview. Feilzer (2010) noted that pragmatism enables researchers to transcend philosophical debates and concentrate on action and change, making it particularly useful in educational research to enhance teaching practices and learning outcomes. Alharahshah and Pius (2020) explain that interpretivism differs from positivism in prioritising the richness of the research context. While positivism seeks objective, measurable data typically detached from context, interpretivism emphasises understanding participants' deeper meanings, experiences, and perspectives within their specific social and cultural settings. This approach values the subjective aspects of reality. It aims to capture the complexity of human experiences, making it especially suitable for studies that focus on comprehending individual or group behaviours in context.

4.3 RESEARCH METHODS

Research methodology is the structured approach that guides the research process, encompassing the strategies, methods, and procedures for gathering and analysing data. It provides a systematic approach to addressing research questions, ensuring the validity and reliability of the findings (Creswell & Creswell, 2021; Kumar, 2019). Research methodology establishes the framework for the study by directing the design, data collection, and analysis processes, thereby ensuring accurate and dependable results (Creswell & Creswell, 2023; Johnson & Christensen, 2023). This framework incorporates ethical considerations and employs appropriate sampling techniques, thereby enhancing the credibility of the research

findings (Flick, 2023). A sample of two teachers from different schools, along with a total of 60 learners (30 from each school), was utilised. Data collection involved interviews with teachers, classroom observations, and semi-structured interviews with both teachers. Pre- and post-tests were administered to assess learners' performance and understanding of DH concepts. Qualitative data was examined through thematic coding, while quantitative data was analysed using statistical methods, including descriptive and inferential statistics (Bryman, 2012). Validity was ensured through triangulation of data sources, and ethical considerations were addressed by obtaining informed consent and maintaining confidentiality. This approach aims to provide insights into effective strategies and challenges in teaching DH within the district, with the findings contributing to improved pedagogical practices (McMillan & Schumacher, 2010).

4.3.1 Research Approaches

Leedy and Omrod (2010) define research approaches as the procedures or strategies employed to find, select, and analyse material regarding a specific issue. These methodologies are generally classified into three primary categories: quantitative, qualitative, and mixed methods research (MMR), each of which is applicable depending on the research setting (Alharahsheh & Pius, 2020). This study employed a combination of qualitative and quantitative methodologies, utilising both primary and secondary data sources. The qualitative data provided supplementary insights that enhanced the quantitative analysis and results (Greener & Martelli, 2018:10). Although quantitative research is prevalent in various sectors, such as SAJEMS (Ngulube & Ngulube, 2015), it is essential to acknowledge that research problems can often be effectively addressed using alternative approaches. Tashakkori and Teddlie (2010) assert that integrating multiple research approaches facilitates a more thorough understanding of complex research problems. Creswell (2014) contends that employing a mixed-methods strategy can yield more comprehensive data and substantial results.

4.3.1.1 Qualitative research Approach

Qualitative research explores and interprets the meanings individuals or groups assign to social or human issues. This approach emphasises evolving questions and methods, gathering data in natural settings, and analysing information inductively to identify broader themes. Researchers interpret the data, and the final report often follows a flexible format. Advocates of this method value its inductive nature, focus on personal perspectives, and its ability to capture nuanced, complex realities (Creswell, 2018).

4.3.1.2 Quantitative research Approach

Quantitative research tests objective theories by analysing relationships between measurable variables. Data is collected through structured instruments and analysed statistically, with findings presented in a standardised report format (introduction, literature review, methodology, results, and discussion). Researchers in this field work deductively, minimise bias, account for alternative explanations, and aim for generalisable and replicable results (Creswell, 2018).

4.3.1.3 Mixed Methods Research Approach

Mixed-methods research integrates both qualitative and quantitative approaches, combining their strengths to enhance the overall rigor of the study. It goes beyond just collecting both types of data by merging philosophical foundations, methodologies, and analytical techniques, resulting in more comprehensive insights than either method alone could provide (Creswell & Plano Clark, 2017).

The research utilised a Mixed Methods Research (MMR) approach, providing a more nuanced understanding of social and economic processes (Balog, 2020). MMR integrates both quantitative and qualitative data, facilitating a thorough examination of the research issue (Creswell, 2018:15). Similarly, Tegan (2021) emphasised that mixed methods research combines aspects of quantitative and qualitative inquiry to address research challenges effectively. This study aimed to identify effective techniques for teaching DH in Grade 10 to enhance learner performance. The researcher employed quantitative and qualitative methodologies, including pre- and post-tests, open-ended interviews, and classroom observations, to achieve the objectives of the study (Poth & Munce, 2020). Quantitative data were initially collected, followed by qualitative, open-ended interviews, which provided in-depth insights from participants and assisted in interpreting the initial quantitative findings (Creswell, 2018:48).

The justification for not selecting alternative approaches is rooted in the quantitative method, which collects data on learners' performance through pre- and post-tests. This method helps validate or disprove hypotheses based on experimental results (Johnson & Christensen, 2020:86). At the same time, the quantitative component examines performance measures; however, it fails to address the qualitative research inquiries regarding the implementation of methods or the perceptions of participants. Qualitative research is prone to biases such as the Hawthorne effect, observer bias, recollection bias, and social desirability bias, which may affect the outcomes (Streefkerk, 2022:04). These issues highlight the necessity of integrating both methodologies to mitigate the limitations of each and provide a more comprehensive view of the research problem.

4.4 RESEARCH DESIGN

MacMillan and Schumacher (2014:28) observed that research design relates to the strategy for conducting a study, encompassing aspects such as duration, subjects, and the methods used for data collection. This aligns with Bairagi and Munot (2019:71), who assert that research design guides the researcher in determining the type of data to be gathered, the methods for data collection, and the ability to derive meaningful insights for the study. Furthermore, Johnson and Christensen (2020:27) argued that the study design must be formulated and executed to effectively address the research questions. Ary et al. (2010:363) further support this viewpoint by outlining six categories of research designs: (a) concurrent design, (b) concurrent triangulation, (c) parallel design, (d) mixed designs, (e) conversion designs, and (f) sequential mixed methods design.

4.4.1 Mixed-method experimental design

This research employed a mixed-methods experimental design with an embedded explanatory component, involving the initial collection and evaluation of quantitative data, followed by qualitative data that provided deeper insights into the quantitative results. This approach integrates qualitative data within the quantitative framework to clarify or elaborate on the initial findings. Employing a mixed-methods experimental design with an embedded explanatory approach across four phases enables researchers to test hypotheses quantitatively in the initial stages while exploring the reasons behind the findings through qualitative inquiry. This integration enhances the validation of hypotheses by offering contextual depth to the quantitative results. Creswell and Poth (2018) maintain that this comprehensive framework fortifies the research design and facilitates a more thorough understanding of complex phenomena, ultimately enriching the interpretation of outcomes. Typically, this design encompasses several phases: 1) **Pre-Test** to assess baseline knowledge, 2) **Qualitative Interviews** to gather insights, 3) **Intervention and Observation** to implement and observe the educational strategy, and 4) **Post-Test** to evaluate the impact of the intervention. According to Creswell and Plano Clark (2021), this design enables researchers to leverage qualitative insights to enhance their understanding of quantitative outcomes, thereby creating a richer narrative. This approach amplifies the explanatory power of research, particularly in educational contexts. See Figure 4.6 of the four phases below.

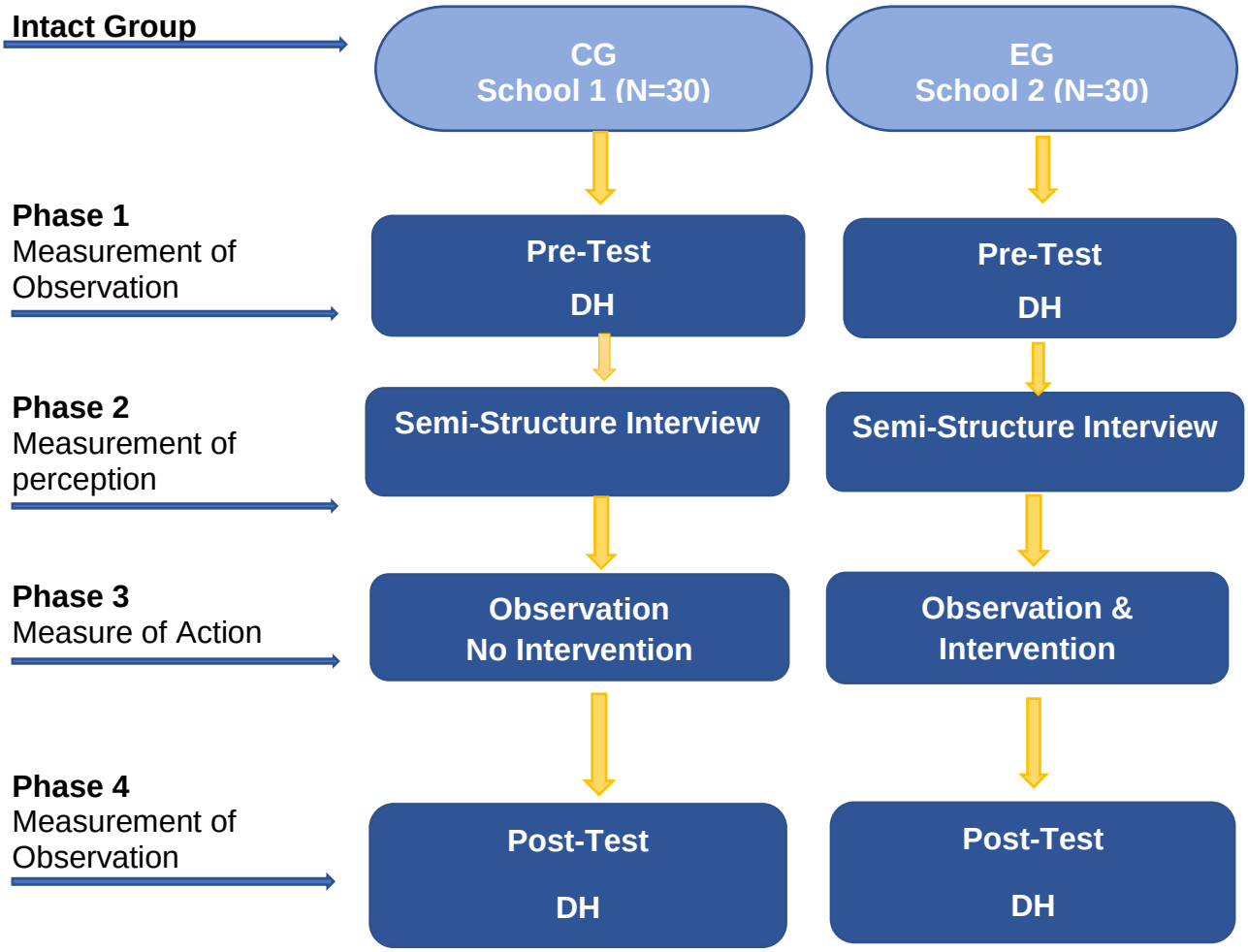

Figure 4.2: ***Four Phases of MM Experimental Design***

Phase 1: Pre-Test (Quantitative Phase)

In Phase 1, CG and EG, each comprising 30 learners, were administered a pre-test to evaluate their initial understanding of DH concepts, including five-number summaries, scatter plots, box-and-whisker plots, and measures of central tendency (see Appendix H). This quantitative assessment is crucial for establishing initial knowledge levels and identifying gaps where understanding is lacking. According to Creswell and Plano Clark (2021), this initial phase sets the stage for later phases by providing a benchmark against which the effectiveness of the intervention can be measured.

Phase 2: Semi-Structured Interview (Qualitative Phase)

Phase 2 consisted of qualitative interviews with selected teachers to gather their perceptions of DH concepts and the challenges they face in teaching. This qualitative data enhanced the understanding of learners' experiences and provided context for the quantitative results from the pre-test. The interviews aimed to identify specific areas where learners struggled, which informed the design of the intervention. (see Appendix K). Phellas, Bloch and Seale (2021) note that capturing learners' voices can offer critical insights into their educational needs.

Phase 3: Intervention and Observation

During Phase 3, the intervention was implemented through collaborative group work, in which more proficient learners supported their peers who struggled with DH concepts. This approach encourages peer teaching and fosters a supportive learning environment that enhances comprehension and confidence. Observations were conducted to assess group dynamics and interactions, providing real-time insights into how CGW facilitates learning (see Appendix M). Johnson et al. (2014) support the effectiveness of CGW in improving learner outcomes, particularly in mathematics.

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Phase 4: Post-Test (Quantitative Phase)

In Phase 4, a post-test was administered to both groups to assess the impact of the CGW intervention on learners' understanding of DH concepts. A comparison of pre- and post-test scores quantitatively measured learning gains and provided insights into the effectiveness of the collaborative approach. Additionally, qualitative data gathered from follow-up interviews revealed learners' reflections on their experiences and their perceived levels of confidence. According to Tashakkori and Teddlie (2010), integrating quantitative and qualitative findings in this phase enhances the overall understanding of the effectiveness of educational interventions, allowing for a more comprehensive analysis of learner outcomes. This assertion is supported by Johnson and Johnson (2020), who emphasise that collaborative learning enhances deeper understanding and improves retention of complex concepts.

Explanatory sequential design

The study employed an explanatory design, which, as Tegan (2021) explained, aimed to identify the causes and effects of the phenomenon being studied. This design involved the initial collection and analysis of quantitative data, followed by the collection and analysis of qualitative data, with the intention of using the qualitative findings to elucidate and interpret the quantitative results.

In the first phase of the study, the researcher utilised quantitative methods to explore the strategies employed to teach DH in Grade 10. Jafer et al. (2020) had further emphasised that integrating quantitative and qualitative data provided a more comprehensive understanding of the phenomenon. The first phase offered an overview, revealing that teachers valued DH, which guided the creation of the interview guide and the selection of teachers for the second qualitative phase. During this phase, the researcher conducted semi-structured interviews to gather in-depth insights into teachers' perceptions of care coordination in DH (Yue et al., 2022). The qualitative data provided a more nuanced understanding of the research question, enabling the researcher to identify key factors that influenced the successful application of teaching strategies in Grade 10 DH (Bashin, 2020).

This design enabled the researcher to develop a robust and accurate understanding of the complex phenomenon, offering valuable insights that could inform the development of interventions and strategies to enhance the performance of Grade 10 learners in DH.

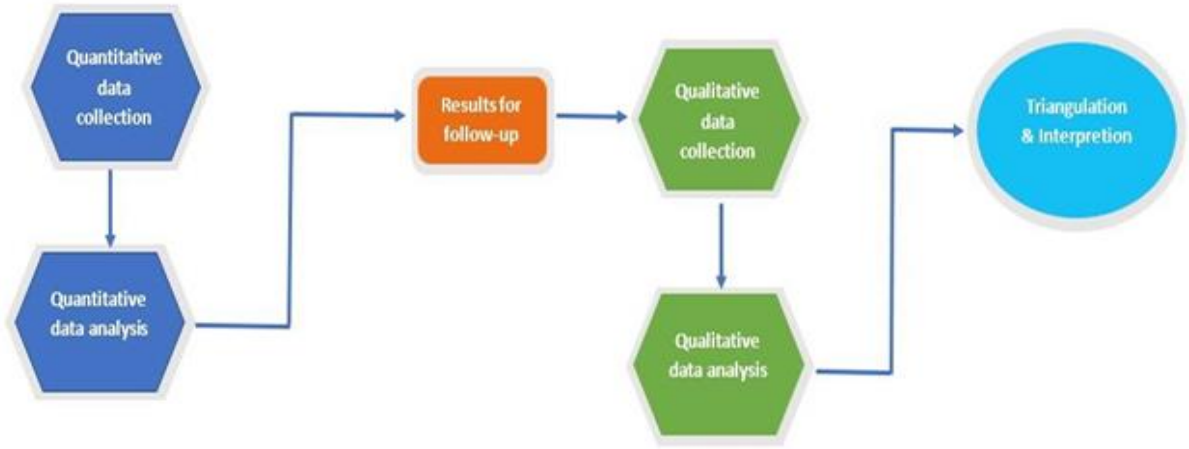


Figure 4.3 ***Explanatory sequential mixed methods design*** (Bunmi, 2020)

The Exploratory and Convergent designs were not employed in this study. Tegan (2021) supports this by stating that exploratory research often relies solely on qualitative methods, which can introduce bias. Elman, Gerring, and Mahoney (2020) also explain that quantitative data are typically collected through surveys, whereas qualitative data are typically collected through semi-structured interviews in a convergent parallel mixed-methods study. However, this design was not used in the current study as it primarily focuses on quantitative data, which does not align with its methodological approach.

4.5 POPULATION

The study was conducted in two selected secondary schools located in the Bonesang Circuit of the Bojanala District, within the North West Province of South Africa. This district was purposefully selected due to its accessibility and relevance to the researcher's context. The North West Province comprises four education districts: Dr Ruth Segomotsi Mompati, Ngaka Modiri Molema, Dr Kenneth Kaunda, and Bojanala. Bojanala, home to approximately 520 secondary schools (NECT, 2024), provided a suitable setting for examining teaching strategies related to DH in mathematics.

To uphold ethical standards and ensure confidentiality, the participating schools were assigned pseudonyms: Kurisani Secondary School served as the control group, while Andzani Secondary School represented the experimental group. These schools were selected as they reflect typical secondary education environments within the district. A total of 60 Grade 10 mathematics learners participated in the study, with 30 learners drawn from each school. All participants were currently engaged in mathematics instruction, making them suitable for evaluating the effectiveness of targeted teaching interventions.

Mathematics teachers from both schools provided insights into their pedagogical approaches, challenges, and perceptions of DH instruction, complementing the learner data. This multi-perspective approach aligns with the recommendations of Smith et al. (2023), who highlighted the value of contextually and practitioner informed research in evaluating educational innovations. The Bojanala District's dynamic educational landscape served as a meaningful backdrop for the study, offering implications for improving curriculum delivery and establishing best practices in similar educational settings across South Africa.

4.5.1 Sampling method

Purposive random sampling (PRS) was employed in a study involving 60 learners, with 30 participants from each of the two schools. The research concentrated on learners enrolled in mathematics classes and their teachers in 2023. PRS is a sampling methodology that blends purposeful and random sampling techniques. This approach enables researchers to focus on a specific population while minimising bias, thereby enhancing the validity of the data (Creswell & Creswell, 2021). Another rationale for employing PRS in research is to ensure that each individual within the defined population has an equal and independent chance of selection (Gay, 1996). Furthermore, Rahman et al. (2022) confirmed that PRS guarantees that every person in a population has an equal opportunity to be selected as a respondent.

To ensure methodological rigor and representativeness, the researcher employed a combination of purposive and stratified random sampling techniques to select participants for the study, which included Grade 10 learners and their mathematics teachers. Although the initial sample target was 30 learners per school, interest exceeded expectations as more than 52 learners returned signed consent forms from both themselves and their parents or guardians. To maintain consistency and manageability, the researcher limited participation to 30 learners per school, following best practices in educational research (Creswell & Creswell, 2021; Cohen, Manion, & Morrison, 2018). A complete list of Grade 10 mathematics learners aged 14 to 16 for the 2022–2023 academic year was compiled at each school. Each learner was assigned a unique identification code (e.g., L1 to L52), and a computer-based random number generator was used to randomly select 30 participants, such as L3, L8, L13, L20, L26, L28, and so on. This ensured that every eligible learner had an equal chance of selection, thereby minimising selection bias and enhancing the study's internal validity (McMillan & Schumacher, 2014).

In parallel, the researcher identified Grade 10 mathematics teachers from each school to participate in the study. Teachers were purposively selected based on their direct instructional roles with the sampled learners, ensuring their insights were relevant and contextually grounded. Including learners and their teachers allowed a more holistic exploration of

instructional strategies, learning challenges, and perceptions surrounding the Mathematics curriculum. “This dual methodology enhances the insights gained from both learners and teachers regarding mathematics instruction (Creswell & Creswell, 2021).” This dual-sample approach aligns with the principles of mixed-methods research, promoting triangulation and strengthening the depth and credibility of findings (Miles, Huberman, & Saldaña, 2014; Creswell & Plano Clark, 2018). The researcher aimed to capture statistical trends and experiential nuances of mathematics teaching and learning by integrating quantitative sampling rigor with qualitative depth.

4.5.2 Schools profile and teachers’ profile

The profiles of the participating schools are compiled in the table below. It includes the total number of teachers, the total number of mathematics teachers, and the teacher-to-learner ratio. The purpose of this table is to showcase the human resource capability of each institution. Teacher 1 instructs Grade 10 at S1, a rural school serving a predominantly black learner body. There are 49 learners too many in their cramped classroom. The school has 980 enrolled learners, yet only 37 teachers. A desk meant for two learners is shared by three. This indicates a shortage of furniture in the classrooms. T1 asserts that incorporating colours should be a priority when teaching DH as they capture learners' attention. Establish school profile, T/L = Teacher/Learner. See Table 4.1 and Table 4.2

Below is **Table 4.1**, which compares the school profiles for the Control and Experimental Grade 10 groups. The table outlines key details, including the number of teachers, teacher-to-learner ratios, and gender distribution in each class. The data interpretation follows the table to offer a clearer understanding of the differences between the two school groups.

Table 4.1: School Profile of Control and Experimental Groups (Grade 10)

School	Group Type	Class	Teachers	T/L Ratio	Girls	Boys	Total Learners
School 1	Control Group	A	1	1:49	19	20	39
		B	1	1:47	17	30	47
School 2	Experimental Group	A	1	1:59	27	32	59

Table 4.1 presents the profile of the two schools participating in the study, comparing the control and experimental groups at the Grade 10 level. School 1, the Control Group, consists of two classes (A and B) with one teacher assigned each, resulting in teacher-to-learner (T/L) ratios of 1:49 and 1:47, respectively. The study focused on Grade 10 learners aged 14 to 16 during the 2022-2023 academic year. The gender distribution across these classes shows a slight predominance of boys over girls, especially in Class B, which has 30 boys and only 17 girls. In contrast, School 2, representing the Experimental Group, has a single Grade 10 class

with one teacher managing a significantly larger cohort of learners, as reflected in a higher teacher-to-learner (T/L) ratio of 1:59. The class also exhibits a more balanced gender distribution, with 27 girls and 32 boys. The data highlights differences in class size and gender composition, which may influence teaching strategies, learner participation, and overall classroom dynamics in each group.

Table 4.2 compares two teachers, T1 and T2, based on key attributes such as gender, age group, qualifications, subjects taught, teaching experience, statistical training, and professional development. This comparison offers insight into the teachers' professional backgrounds, which may influence their teaching methods and pedagogical approaches.

Table 4.2: Teacher's Profile

Attribute	T1 (Teacher 1)	T2 (Teacher 2)
Gender	Male	Female
Age-Group	30-36	45-50
Qualification	Med (Master's Degree)	Diploma
Subjects Teaching	Maths, Tech & MLT	Maths & P/Science
Years of Experience	2 to 6 months	11 Years
Statistical Course	Yes	No
Professional Development Workshop	Yes	No

Table 4.2 compares the profiles of two teachers, T1 and T2. Teacher T1 is a male, aged between 30 and 36 years, with a Master's degree (Med) and teaches Mathematics, Technology, and Medical Laboratory Technology (MLT). He has 2 to 6 months of teaching experience, completed a statistical course, and attended a professional development workshop, focusing on developing his teaching skills and knowledge. On the other hand, Teacher T2, a female aged between 45 and 50 years, holds a Diploma and teaches Mathematics and Physical Science. With 11 years of teaching experience, T2 has not participated in a statistical course or professional development workshops, suggesting a more traditional approach to her teaching career. These differences in qualifications, teaching experience, and professional development could influence their effectiveness and the methods they used in the classroom.

4.6 DATA COLLECTION PROCESS

This study employed a sequential mixed-methods research design to evaluate the effectiveness of a newly introduced teaching strategy for enhancing learners' understanding of DH. The data collection process was organised into three phases: pre-application, during application, and post-application. In the pre-application phase, a quantitative pre-test was administered to all EG and CG school learners to establish baseline knowledge levels. Simultaneously, qualitative data were gathered through semi-structured interviews with two teachers, one from each school (T1 and T2). These interviews provided foundational insights into each teacher's instructional strategies, perceived challenges in teaching DH, and contextual factors that influence learner performance. Creswell and Creswell (2023) note that such preliminary qualitative engagement allows researchers to identify the contextual variables that may influence subsequent phases of the study.

During the application phase, qualitative data collection continued through classroom observations and follow-up interviews, with a specific focus on the experimental school. These observations were used to monitor the implementation fidelity of the new strategy and capture real-time teacher-learner interactions, instructional techniques, and learner engagement. Interview sessions with the EG teacher (T2) following these observations provided an opportunity for reflective feedback and allowed for the adaptation of strategies as needed. Teddlie and Tashakkori (2022) argue that integrating observational and interview data offers valuable insights into the instructional processes and supports the development of contextually grounded explanations. Such depth of analysis not only enhances understanding of pedagogical practices but also supports the iterative refinement of interventions during implementation.

In the post-application phase, both schools administered a quantitative post-test to assess the intervention's impact, enabling a direct comparison of performance between the experimental and control groups. The post-intervention data collection also included additional observations and teacher reflections, enriching the contextual understanding of learner outcomes. This triangulated design, which combined pre- and post-test results with interview and observation data, ensured both methodological rigour and a nuanced interpretation of the findings. By aligning quantitative measures with qualitative insights, the study meets the standards of validity and comprehensiveness recommended by mixed-methods scholars (Creswell & Creswell, 2023; Teddlie & Tashakkori, 2019). This integrated approach facilitates a holistic evaluation of teaching effectiveness, offering evidence-based recommendations for improving DH instruction in similar educational contexts.

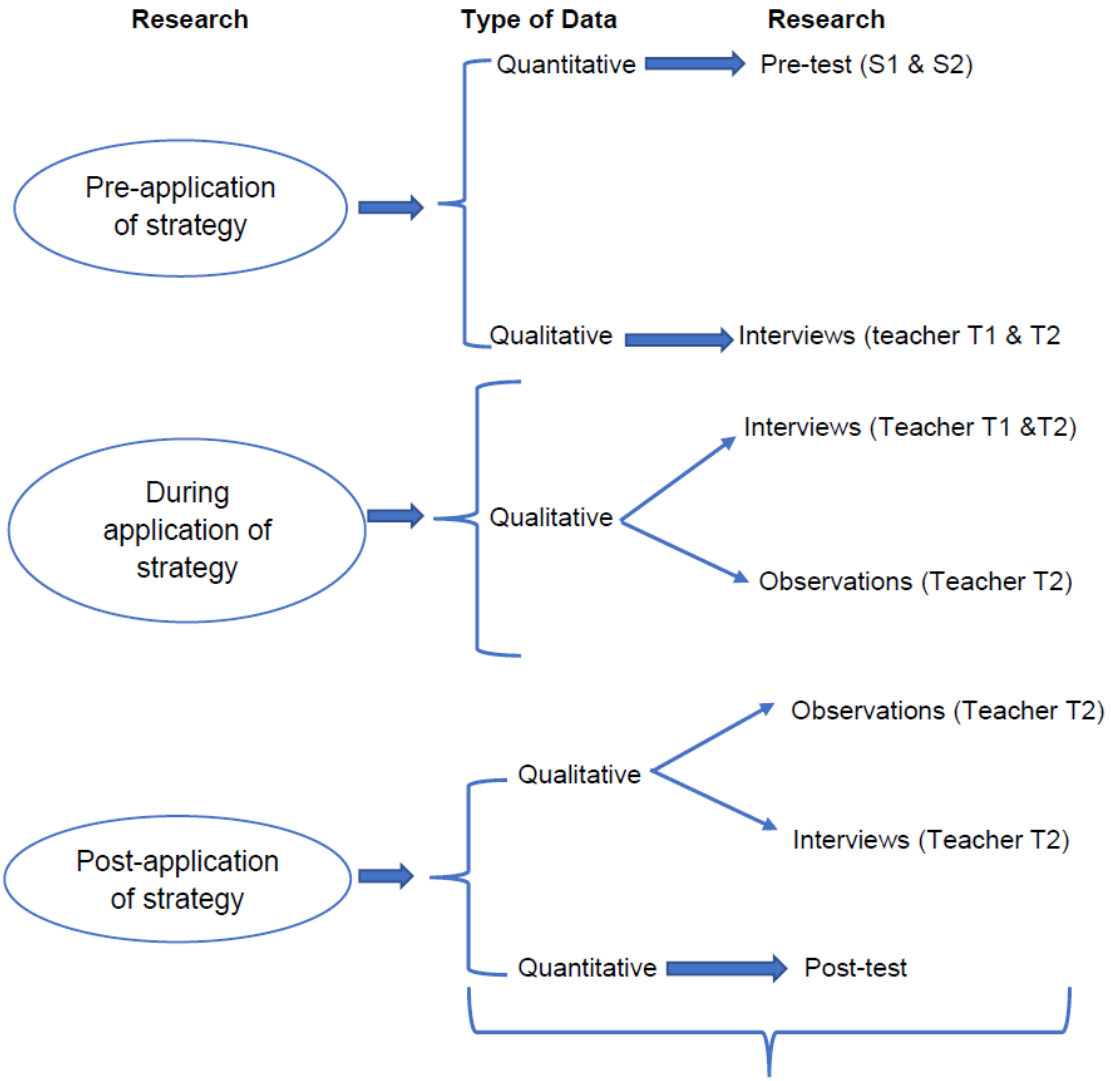


Figure 4.4: ***Analytical framework: Mixed methods integrated with Action Research*** (Makgakga, 2016:114)

4.6.1 Pilot study

A pilot study was conducted to evaluate the data collection instrument prior to the commencement of the primary research. The instrument piloted was a pre-test questionnaire to assess key variables relevant to the main study. The pilot was conducted with a small group of 15 learners from another school within the Bojanala district, which was not included in the main study, to prevent any bias or contamination of the results. According to Muresherwa and Jita (2022), pilot studies are crucial in educational research to evaluate the relevance and functionality of research tools prior to the primary data collection process.

The purpose of the pilot was to ensure that the instrument effectively measured the intended constructs, to evaluate the practicality of administering it, and to identify any areas that

required improvement. Pilot studies provide an opportunity to refine the instrument's design, address logistical issues, and evaluate administration procedures in real-world contexts (Jiménez-Rodríguez et al., 2021). The pilot allowed the researcher to gain insights into the questionnaire's clarity, reliability, and feasibility, which are crucial for the success of the main study.

During the piloting phase, several ambiguities were identified, particularly in the phrasing of specific questions and the clarity of instructions. Some participants misinterpreted questions due to vague wording or lack of context. These issues are common in early drafts of research tools and can significantly affect the quality of the data collected (Gani, Rathakrishnan & Krishnasamy, 2020). In response, the researcher made several adjustments, including rewording confusing questions, simplifying instructions, and reorganising the sequence of questions to enhance logical flow and understanding. These refinements enhanced the validity and reliability of the instrument, ensuring that the main study would proceed with a more robust data collection tool.

Stage 1: Pre-application of the Strategy

During the pre-application stage, quantitative data were collected by administering a pre-test to 60 learners, divided into two groups: a control group (CG) and an experimental group (EG), each comprising 30 learners. The objective of this pre-test was to establish a baseline measure for evaluating the impact of teaching styles on learner performance. Concurrently, qualitative data were collected through semi-structured interviews with two teachers: T1 from the CG and T2 from the EG. The interviews sought to gather teachers' insights regarding their pedagogical methods and expectations, providing essential context to complement the quantitative data. The study aimed to comprehensively understand the initial conditions for both groups by integrating quantitative assessments with qualitative observations. See Appendix H (for pre- and post-tests) and Appendix K (for interviews).

Stage 2: During the Application of the Strategy

The second stage focused on qualitative data collection, enabling an in-depth exploration of the implementation of the teaching strategy. Semi-structured interviews with teachers (T1 and T2) continued to capture their ongoing reflections and experiences throughout the intervention. Furthermore, observations were conducted explicitly for the EG (S2) to document T2's teaching practices in real time. This observational data provides valuable insights into how the strategy was enacted in the classroom, capturing the dynamics between the teacher and learners and any challenges faced during implementation. Moreover, classroom observations centred solely on T2, the teacher for the EG, to furnish a detailed account of how the intervention was applied in practice. This stage sought to gather real-time feedback and

insights, thereby enhancing the understanding of the contextual factors influencing the intervention's implementation. This phase emphasises the importance of considering contextual factors in assessing the effectiveness of educational interventions. See Appendix M (for observations) and Appendix K (for interviews).

Stage 3: Post-application of the Strategy

In the post-application stage, a mixed-methods approach was again employed. The EG (S2) underwent a quantitative post-test to measure changes in learner skills following the intervention. This post-test directly compares outcomes with the pre-test data, allowing for an evaluation of the strategy's effectiveness. Simultaneously, qualitative data were collected through observations of T2 and a semi-structured interview with T2 to gain insights into the overall impact of the intervention and any observed changes in teaching practice or learner engagement. This stage emphasises the importance of reflective practice among teachers and highlights the connection between qualitative insights and quantitative outcomes. This methodology aligns with contemporary guidelines for mixed-methods research in education, emphasising the need for a comprehensive understanding of complex educational processes (Creswell & Creswell, 2023; Teddlie & Tashakkori, 2022). See Appendix H.

4.6.2 Pre-test and post-test as a data collection process

This study involved 60 learners from two different schools. 30 from School 1 as the control group (CG) and 30 from School 2 as the experimental group (EG). The tests took place after school hours to minimise disruptions to teaching and learning. The study was conducted in the afternoons and on weekends to prevent interruptions to regular lessons, focusing on a sample of 30 learners. In contrast, others were dismissed to ensure full attention was paid to the selected group. This timing also allowed non-participating learners to remain at home. Creswell and Creswell (2023) highlight that scheduling research activities to minimise disruption enhances the study's focus and maintains educational integrity. To avoid inconveniences, learners wrote the test in their respective classrooms. The tests lasted for 60 minutes and were administered on the same day in both schools. All 60 learners were informed about the test's purpose and the scheduled date (see Appendix F) prior to its administration. The pre-test was administered after the DH concepts were taught, as outlined in the curriculum and Annual Teaching Plan (ATP) for the Department of Basic Education. Before the intervention, a pre-test is administered to both groups to establish a baseline of performance. This dual assessment approach not only provides quantitative data but also facilitates an understanding of the effectiveness of instructional methods over time (Creswell & Creswell, 2023; Teddlie & Tashakkori, 2022). Figure 4.6 summarises how the pre-test and post-test were conducted in the EG and CG. See Figure 4.6 below.

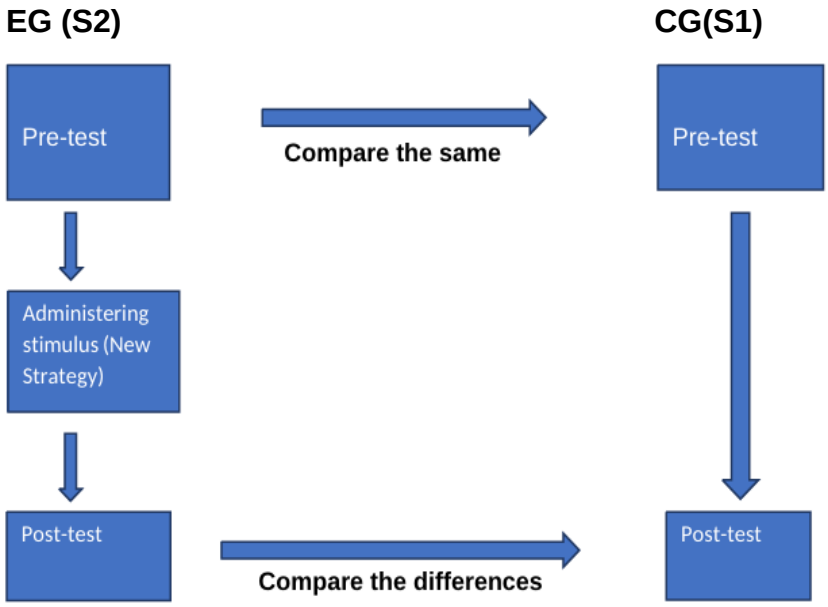


Figure 4.5: ***Illustration of a basic experimental comparison design*** (Babbie, 2020:238)

The researcher arrived with the pre-test papers on the day the test was conducted. They discussed the timing and invigilation procedures with the participating teachers who had assisted them in advance. With the support of the teachers at their respective schools, the researcher moved between them to ensure a reliable assessment. The researcher collected the learners' answer scripts from both schools on the same day for marking and analysis. Creswell and Creswell (2023) note that post-test results, when analysed alongside pre-test data, can reveal the magnitude of the intervention's impact, providing valuable insights into its effectiveness. According to Creswell and Creswell (2023), pre-test data enable a comparison of groups prior to the introduction of the experimental treatment, ensuring that any differences in post-test results can be attributed to the intervention rather than pre-existing differences. This initial assessment establishes a clear baseline for measuring the impact of the teaching strategy. Following the pre-test, a post-test was administered to both groups after the teaching strategy was applied exclusively to the experimental group. The researcher marked the scripts for both tests to evaluate how learners responded to the questions and assess their overall performance (McMillan & Schumacher, 2014:298). This process facilitated an analysis of the intervention's effectiveness. The basic experimental comparison design, illustrated in a diagram format, offers a clear framework for evaluating the effectiveness of educational interventions through pre-test and post-test assessments. This design typically involves two groups: a control and an experimental group. Both groups are subjected to a pre-test, allowing researchers to establish a baseline measurement of learners' knowledge or skills before the intervention occurs.

Following the pre-test, the EG engages with the new teaching strategy while the CG continues with traditional instruction. This controlled approach is essential for isolating the effects of the intervention. After the intervention, a post-test is administered to both groups to assess any changes in knowledge or skills. The results from the post-test provide quantitative data that can be analysed for significance, revealing whether the EG outperformed the CG due to the intervention. Overall, the basic experimental comparison design is a robust method for educational research, allowing for clear causal inferences regarding the impact of interventions on learning outcomes. By systematically comparing pre-test and post-test results, researchers can contribute to evidence-based practices in education, aligning with the recommendations of contemporary scholars (Creswell & Creswell, 2023; Teddlie & Tashakkori, 2022). This structure enhances the reliability of findings and supports informed decision making in educational contexts.

4.6.3 Classroom observation

The researcher utilised lesson observation tools as part of the data collection process to gain a deeper understanding of the teaching methods employed in the classroom. Halim (2018) maintains that classroom observation involves observing teachers' and learners' behaviours and performances in the school. The researcher aimed to observe the natural dynamics of teaching and learning, specifically focusing on how DH concepts were taught and understood in real-time (Mligo, 2016:48). Acting as a passive observer, the researcher concentrated on gathering data during instructional periods, as highlighted by Mills (2018). The focus was on four key aspects of DH: measures of central tendency, the five-number summary, stem-and-leaf plots, and box-and-whisker plots. These observations were conducted in the EG and CG to assess how learners engaged with DH content. By observing lessons in this manner, the researcher was able to generate firsthand information, directly experiencing what occurred during the teaching and learning process (Flick, 2018:314). The observation sessions lasted between 20 and 45 minutes for each participant, and the process spanned three months during the second term of 2023. This timeframe enabled the researcher to gain a comprehensive understanding of the teaching strategies employed. The primary focus of the observations was to analyse the interactions between the teacher and learners within the classroom environment, providing insights into the effectiveness of various instructional approaches for teaching DH concepts. Through these observations, the researcher identified key moments in the learning process and evaluated the learners' understanding and engagement.

The findings were then used to inform the overall Assessment of the impact of the teaching strategy on learners' knowledge of DH concepts. The researcher focused on observing the following aspects of the teacher's lesson (see Appendix M).

1. The dynamics of teaching and learning in the mathematics classroom.
2. The teaching strategies employed throughout the lesson.
3. The types of questions used to engage learners and the assessment methods applied.
4. How teachers support learners who face learning challenges.
5. The reasons for assessing learners during or after the lesson.
6. The types of resources utilised in the teaching and learning process.

4.6.4 Semi-structured interviews

In this study, the researcher employed semi-structured interviews with two Mathematics teachers from different schools immediately following the pre-test. According to Keller et al. (2020), semi-structured interviews incorporate both closed-ended and open-ended questions, along with probing inquiries such as "why" or "how," which facilitate the introduction of new topics during the interview. Semi-structured interviews provided a deeper insight into the teachers' perspectives on the challenges learners face in DH. This method was selected for its flexibility in gathering the teachers' views and perspectives on DH teaching strategies. Participants were permitted to respond independently, free from external influence. The interview responses were later transcribed into a document for analysis and review.

Tegan and Merkus (2022) noted that asking set questions in a specific order facilitates the comparison of responses among participants within a consistent framework. Doyle (2020:2) explained that a semi-structured interview enables the interviewer to move beyond a rigid list of questions by employing open-ended queries that encourage dialogue and exploring topics with the interviewee. This approach enabled the researcher to gather more in-depth and nuanced responses, yielding valuable insights into teachers' practices and the challenges they face in teaching DH. While a structured interview consists of fixed questions that do not permit divergence, the analysis of the semi-structured interviews was conducted prior to implementing DH teaching strategies.

The two teachers were asked the following questions, which are classified in italics: (see Appendix K).

Challenges of DH: 1. *What elements do you suppose may be contributing to learners' poor performance in the concept of DH, and why?*
Classroom Interaction: 2. *How do you engage your learners in teaching and learning about DH?*
Teaching and Learning Materials: 3. *What materials do you use to teach DH?*

Classroom Assessment: 4. *What assessments do you use in the DH classroom?*
Learner Support in Mathematics: 5*. What kind of assistance do you provide to problematic learners?*
Class Culture: 6. *How do you foster a culture of teaching and learning in your DH classroom?*

4.7 ACTION RESEARCH

Bogdan and Biklen (1992:223) define action research as the systematic collection of data to facilitate social change. Cameron-Jones (1983) characterises action research as an investigation by practitioners to enhance and deepen their understanding of their professional practice. According to Wright and Bailey (1991:207), action research is primarily utilised to tackle challenges in specific settings or to improve certain conditions (Cohen, 1989:118). Sagor et al. (2017:180) argue that action research facilitates the implementation of solutions to address existing problems.

4.7.1 Benefits of Action Research

The study employed action research exclusively while implementing the intervention for the EG. When action research is used to analyse instructional practices for developing higher-order thinking (DH) in mathematics education, it offers significant benefits. One major advantage is its focus on continuous development through reflective practice. Using action research, teachers can systematically examine the effectiveness of various teaching strategies, including visual aids, to convey DH concepts. This reflective process allows teachers to identify what works best for their learners, adjust their methods accordingly, and ultimately enhance the learning experience (Creswell & Creswell, 2021). Furthermore, action research promotes a data-driven approach to teaching. Teachers gather and analyse data on learner performance to make informed decisions about instructional adjustments. For example, if a particular strategy fails to yield the desired understanding, teachers can revise their approach based on empirical evidence, resulting in more effective teaching practices (Stringer, 2014). This emphasis on data allows teachers to monitor progress over time, ensuring their methods remain consistently aligned with learner needs and learning objectives.

Another benefit of action research is that it promotes teacher collaboration and professional development. By sharing insights and outcomes from their research, teachers can build a community of practice that fosters collective learning. This collaborative environment encourages teachers to explore innovative strategies and support one another in addressing everyday challenges in teaching DH (McNiff & Whitehead, 2011). Ultimately, action research enhances the effectiveness of teaching strategies in DH and fosters a culture of inquiry and collaboration, ultimately leading to improved educational outcomes for both teachers and learners. This reflective practice enables teachers to critically analyse their interventions,

assessing what worked well and identifying areas for improvement based on learner performance and engagement. For instance, teachers can consider how specific approaches, such as collaborative learning or technology integration, influenced learners' comprehension and motivation (Creswell & Creswell, 2021). Moreover, involving learners in the reflection process enhances their ownership of learning, providing valuable insights that can inform future instructional decisions.

4.7.2 The Process of Action Research

Action research is a reflective pedagogical technique that teachers use to enhance teaching methods and improve learner learning outcomes. The iterative process includes four stages: planning, acting, developing, and reflecting (Mertler, 2021). Action research deepens understanding of the dynamics of teaching and learning by encouraging collaboration and active participation among teachers (Cochran-Smith & Lytle, 2009). It enables teachers to adapt their strategies based on real-time feedback and data, fostering a responsive educational culture (Kemmis & McTaggart, 2014). Ultimately, action research is vital for ongoing professional development and educational advancement. Figure 4.7 illustrates the four stages of the action research cycle, along with the specific research activities to be conducted at each stage.

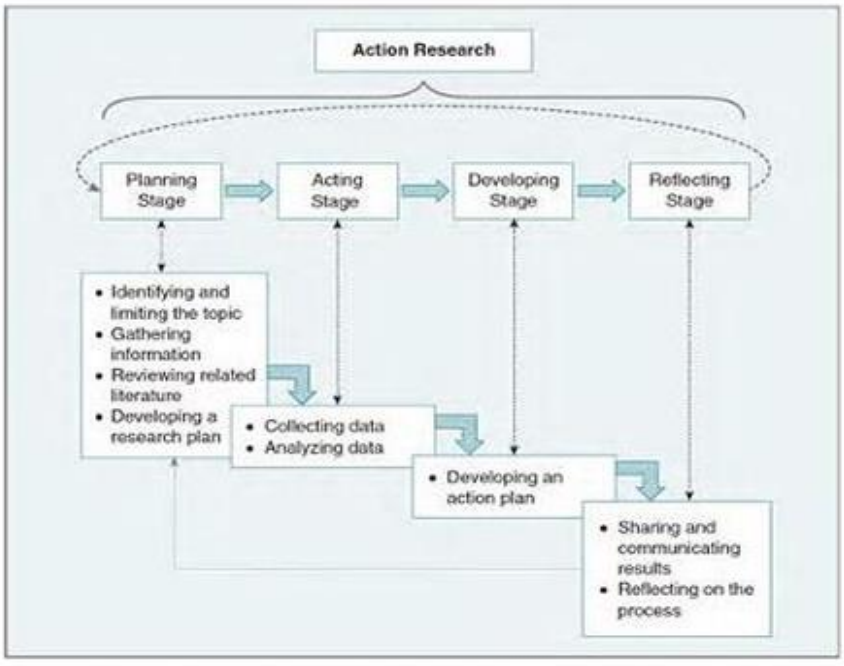


Figure 4.6 ***The Four Stages of Action Research*** (Mertler, 2020:37)

4.7.2.1 The 1st stage: planning stage(

In the first stage of action research, the researcher collaborates with the teacher to identify specific learning challenges faced by Grade 10 learners based on pre-test results in DH concepts. For instance, if analysis reveals that many learners struggle with key areas such as

the five-number summary and the interpretation of scatter plots. This stage involves in-depth discussions to pinpoint the content areas where learners are faltering and the underlying reasons for their difficulties, such as gaps in prior knowledge or a lack of confidence. By clearly articulating the problem, the teacher and researcher establish a focused framework for their intervention, ensuring that subsequent strategies are tailored to address the learners' identified needs directly. As Mertler (2021) notes, a well-defined problem is crucial as it guides the subsequent phases of the research process.

4.7.2.2 The 2nd stage: acting stage

Following the identification of the problem, the researcher assists the teacher in developing a targeted action plan that integrates collaborative group work as a primary intervention strategy. The plan is designed to facilitate peer learning, wherein more capable learners are paired with those struggling to support their understanding of DH concepts. This encompasses structured activities in which learners collaboratively create five-number summaries, interpret scatter plots, and draw box-and-whisker plots. The researcher provides resources and guidance on implementing CGW effectively, ensuring that the activities promote learner interaction and dialogue.

4.7.2.3 The 3rd stage: The acting stage

During the implementation stage, the researcher supports the teacher in executing the action plan through collaborative group work activities. Learners are strategically grouped to maximise collaboration, with advanced learners leading discussions and guiding their peers through problem-solving processes. The researcher observes these group dynamics, providing feedback on effective strategies for peer scaffolding and ensuring that all learners are engaged in the learning process. Throughout this phase, formative assessments, such as observations, group presentations, and reflective journals, are employed to monitor progress and understanding. Dufour and Mattos (2013) state that effective collaboration among learners can yield improved outcomes and deeper comprehension. This hands-on approach enables learners to assimilate new information more effectively as they actively participate in discussions and receive immediate feedback from their peers, enhancing their understanding of developmental health concepts.

4.7.2.4 The 4th stage: action research process

After the CGW intervention, the final stage involves reflecting on the outcomes of the implemented strategies before administering the post-test. The researcher and teacher collaboratively analyse the data collected during the intervention, focusing on improving learners' understanding of the five-number summary, measures of central tendency, and their ability to interpret scatter and box-and-whisker plots. This reflection also encompasses

gathering qualitative feedback from learners about their experiences in CGW, particularly regarding how peer scaffolding has impacted their learning. By critically evaluating the effectiveness of the CGW intervention, teachers gain valuable insights that inform future instructional practices and help refine strategies for supporting all learners. This reflective practice contributes to the teacher's professional growth. It fosters a culture of continuous improvement, ensuring learners are better prepared for the post-test and future learning in DH. As McNiff and Whitehead (2011) emphasised, reflection is integral to the action research process, nurturing a culture of continuous improvement that enhances teaching practices and better prepares learners for future challenges in DH.

4.8 VALIDITY AND RELIABILITY

Validity indicates whether an instrument measures or describes what it is intended to measure or explain. This was confirmed by Sürücü and Maslakçi (2020), who stated that using a validated measuring tool assures that the findings obtained from the analyses are valid. Creswell (2018) further supports this by explaining that reliability in assessment instruments refers to the consistency of the tool. It involves ensuring that the instrument has been tested for internal consistency and administered multiple times to guarantee stable results with each use. Additionally, Sebsibe (2019) describes a research instrument as reliable if it is administered to similar sets of respondents in comparable situations and produces identical results. This is also echoed by Sürücü and Maslakçi (2020), who note that reliability is not only an attribute of a measuring instrument but also an attribute of the results produced by the measurement.

4.8.1 Validity of pre- and post-test

In this study, the validity of the pre- and post-tests was rigorously examined to evaluate learners' competencies and understanding of differential calculus (DH). The pre- and post-test items were adapted from past National Senior Certificate (NSC) examination questions, which are aligned with the Curriculum and Assessment Policy Statement (CAPS). These items had undergone prior validation by the Department of Basic Education (DBE) and its quality assurance body, Umalusi, ensuring alignment with national standards for content validity and curriculum coherence.

To further enhance the validity of the assessment instruments, the researcher engaged two subject matter experts in Mathematics Education from the Bojanala District. These included a Subject Advisor specialising in the Further Education and Training (FET) phase and a Head of Department (HOD) with over 13 years of classroom experience. These experts reviewed the test items for both content and construct validity. Mohajan (2017) and Taherdoost (2016) articulated, content validity ensures that an instrument comprehensively captures all relevant

components of the construct being measured, while construct validity assesses whether the instrument accurately reflects the theoretical concept it intends to measure. Additionally, the reliability of the instrument, which refers to its consistency and stability across contexts and over time, was considered alongside validity, which addresses the accuracy and appropriateness of the measurement (Creswell & Creswell, 2018). Expert judgment, curriculum alignment, and past empirical validation collectively contributed to the robustness and credibility of the assessment tools used in this study (see Appendix E).

4.8.2 Reliability of pre- and post-test

In this study, the reliability of the assessment was determined through a pre-test and a post-test. The pre-test (refer to Appendix H) aimed to evaluate the participants' understanding of the school's DH curriculum. Furthermore, all raters unanimously agreed that the provided memorandum was adequate and suitable for assessing the concept mapping exercise. To establish the reliability of the concept mapping, two mathematics teachers who were not involved in the study and operated outside the study site were given the pre-test and the memorandum (see Appendix I). This approach ensured that there was no potential bias or contamination from those directly involved in the research. The responses from the mathematics learners demonstrated a strong alignment with the anticipated answers in the memorandum, indicating consistency. Specifically, the learners' responses agreed with how DH topics should be listed by grade level and the logical and hierarchical order in which these topics should be taught.

The consistency among the responses from both learners and teachers confirmed that the concept test is sufficiently reliable for assessing teachers' knowledge of DH within the school's mathematics curriculum (Roberts, 2020). Where necessary, their feedback was utilised to revise the concept mapping exercise and memorandum before the main study.

Moreover, ensuring the reliability of an instrument is vital for the credibility of the research findings (Creswell, 2014). The involvement of external raters in evaluating the test items helped reduce the risk of bias and ensured that the content was measured accurately across various contexts (Bryman, 2016). The use of external raters also offered an opportunity for peer review, which is crucial for enhancing the quality and reliability of the research instrument (Field, 2013). These measures collectively strengthen the reliability of the assessment tool, ensuring that it effectively measures its intended objectives.

4.9 TRUSTWORTHINESS

According to Lincoln and Guba (1985), trustworthiness is a crucial element that enables researchers to demonstrate to themselves and their audience that their research findings are

reliable and worthy of attention. The importance of ensuring quality in qualitative research has been a significant topic of discussion among scholars for many years (e.g., Denzin & Lincoln, et al, 2011), with various strategies available to maintain rigor and trustworthiness in qualitative studies. Lincoln and Guba (1985) argue that evaluating the trustworthiness of a research study is essential for assessing its credibility and significance. Trustworthiness is based on four key principles: credibility, transferability, dependability, and confirmability.

4.9.1 Credibility

Credibility can be enhanced through strategies such as prolonged engagement, persistent observation, triangulation, and member checks (Lincoln & Guba, 1985). In qualitative research, credibility is analogous to internal validity in quantitative studies, focusing on the accuracy and truthfulness of the findings. Prolonged engagement refers to spending an extended amount of time in the field to establish trust with participants and to gain a more comprehensive understanding of their experiences. For example, if researchers conduct semi-structured interviews with teachers over several weeks, they can observe how teaching strategies are implemented in real time. According to Lincoln and Guba (1985), this depth of engagement enables researchers to grasp the complexity of the educational environment, thereby enhancing the credibility of their findings.

Persistent observation is another method that contributes to credibility by focusing on specific aspects of the data that are most relevant to the research questions. In the context of teaching DH, researchers may observe classes where teachers employ various strategies, such as interactive simulations or group project-based exercises. By closely monitoring these teaching moments, researchers can gather rich, contextual data that informs their analysis (Merriam, 2016).

Triangulation enhances the credibility of a study by integrating multiple data sources to validate findings through cross-verification. In this research, triangulation was achieved by combining semi-structured interviews with teachers, analysis of learner performance data, and feedback from learners regarding their learning experiences. This multi-faceted approach enabled the identification of consistent patterns across datasets, thereby strengthening the reliability of the conclusions (Denzin, 1978). Additionally, member checking was employed as a strategy to ensure the authenticity of the data interpretation. After interviews, summaries of the teachers' instructional strategies were shared with participants to confirm that their perspectives had been accurately captured. This process not only affirmed the trustworthiness of the researchers' interpretations but also allowed participants to provide clarifications where necessary. As noted by Cohen, Manion, and Morrison (2018), member checks play a critical

role in reinforcing the credibility of qualitative research by validating the alignment between the researchers' analysis and the participants' intended meanings.

Moreover, several deliberate actions were taken to ensure the credibility of this study. First, triangulation was employed by collecting data from teachers and learners, allowing for cross-verification and consistency of findings (Creswell & Creswell, 2018). To validate the assessment instruments, two independent Mathematics Education experts, a Subject Advisor and an experienced Head of Department, reviewed the pre- and post-tests for content and construct validity. Their recommendations informed necessary revisions (Taherdoost, 2016; Roberts, 2020). A pilot study was conducted to pre-test the instruments, ensuring clarity and appropriateness before the main study. Member checking was also utilised by sharing synthesised responses with selected participants to confirm the accuracy of interpretations (Birt et al., 2016). Furthermore, two external raters assessed open-ended responses to enhance objectivity and inter-rater reliability (Heale & Twycross, 2015). These steps, along with detailed documentation of the research process, contributed to the trustworthiness and credibility of the study.

4.9.2 Transferability

This insight enables teachers to evaluate whether similar strategies could be effective in their classrooms, even if the specific contexts differ. Transferability relates to the generalisability of inquiry (Korstjens & Moser, 2018:121). Sharing these examples, along with the challenges and successes they entail, offers valuable insights that other teachers can adapt to their unique circumstances. Establishing transferability, Charmaz (2022) emphasises that when researchers provide detailed descriptions of the educational setting, participants, and teaching methodologies, it enhances the understanding of how findings can be applied elsewhere. By showcasing various strategies and their outcomes in different Grade 10 classrooms, the study contributes to a broader understanding, encouraging teachers to reflect on how these strategies might be adapted to their own practices.

To ensure the transferability of the study, the researcher took several actions aligned with established qualitative research practices. Specifically, the researcher provided thick, rich descriptions of the research setting, including the school's socio-economic context, the grade level of participants, the CAPS-aligned mathematics curriculum, and the professional backgrounds of the teachers involved. According to Lincoln and Guba (1985), such contextual detail enables other researchers and teachers to determine whether the study's findings can be meaningfully applied to similar contexts. Furthermore, researchers described the instructional strategies, assessment instruments (such as the concept-mapping tasks), and data collection procedures in detail to support the transparency and replicability of the

research design. As Tracy (2010) noted, transferability is strengthened when readers are equipped with sufficient information to make informed comparisons with their own settings. These measures collectively support the applicability of the findings beyond the immediate research site.

4.9.3 Dependability

Dependability ensures that the results can be trusted and replicated under similar conditions. By systematically recording and analysing these discussions, researchers can establish a reliable account of the strategies employed in the classroom. According to McMillan and Schumacher (2010), clarity and coherence in reporting such findings enhance the study's dependability, enabling others to grasp the rationale behind each strategy and its implementation. Dependability can be strengthened through audit trails**,** which involve thoroughly documenting the research process, including the development of interview questions, participant selection, and data analysis procedures. This transparency allows other researchers to follow the same steps and assess the consistency of the findings. For instance, if the same semi-structured interview format is utilised with additional teachers in different schools, and similar themes regarding effective DH strategies emerge, this convergence further reinforces the dependability of the original study's findings. Teachers and researchers can offer valuable insights into effective teaching strategies for DH through the dependability of the research process and its findings. This not only contributes to the trustworthiness of the study but also facilitates the sharing of best practices across diverse educational settings.

To ensure the dependability of the study, the researcher implemented several rigorous strategies grounded in established qualitative research practices. First, a comprehensive audit trail was maintained throughout the research process, systematically documenting each phase, from the design and piloting of data collection instruments to data analysis and interpretation. This included detailed research memos, decision-making records, and a log of modifications made in response to expert input and pilot study findings (Lincoln & Guba, 1985). In addition, a code recode strategy was employed during the qualitative data analysis phase, wherein initial coding was revisited after a two-week interval to assess the stability and consistency of interpretations (Merriam & Tisdell, 2016). To further enhance analytical rigor and reduce potential researcher bias, peer debriefing was conducted with a qualified academic colleague who critically examined the coding scheme and emerging themes (Nowell et al., 2017). Collectively, these measures strengthened the dependability of the research by ensuring that the processes followed were logical, traceable, and consistently applied.

4.9.4 Confirmability

Confirmability in studies exploring teaching strategies can be maintained throughout these interviews by keeping an audit trail documenting each step of the data collection process, including the interview questions, responses, and any notable deviations from the planned approach (Lincoln & Guba, 1994). Confirmability involves peer debriefing, where the researcher discusses the research process and findings with experts or colleagues to ensure the validity of the research. This transparency allows other researchers to verify the authenticity of the findings. Additionally, employing reflexivity is essential. Since the researcher had a background in mathematics education, they maintained a reflexive journal to reflect on how their perspectives might influence the interpretation of the data. They noted instances where they felt an implicit bias toward specific teaching methods, ensuring that their analysis remained grounded in the teachers' narratives rather than their preferences. By maintaining confirmability through audit trails and reflexivity, the researchers demonstrated that their findings accurately reflected the teachers' experiences, rather than merely reflecting their own biases. This approach enhanced the study's trustworthiness and provided meaningful insights into effective teaching strategies for Grade 10 DH.

To ensure the confirmability of the study, several key actions were taken to minimise researcher bias and ensure that the findings were rooted in the participants' perspectives. A detailed audit trail was maintained, documenting key decisions throughout the research process, ensuring transparency and traceability of the findings (Lincoln & Guba, 1985). Additionally, peer debriefing was employed with an external researcher not involved in the study to review and discuss the analysis and emerging themes, providing an external check on the data interpretation. Furthermore, reflexivity was practised by regularly reflecting on the researcher’s role and the potential influence of personal biases on the study. These steps ensured the findings were based on the participants' voices rather than the researcher's assumptions or preconceptions.

4.10 DATA ANALYSIS

Data analysis is a comprehensive process that involves the investigation, cleaning, transformation, and modelling of data to extract valuable insights, draw conclusions, and inform decision making. It integrates quantitative methods, such as statistical analysis, with qualitative techniques, including thematic analysis, to provide a comprehensive interpretation of the data (Creswell & Creswell, 2021; Field, 2018). Data analysis aims to judiciously employ statistical and logical tools to characterise, summarise, and compare data to derive significant conclusions.

The study involved 60 Grade 10 learners, divided into a control group of 30 and an experimental group of 30. The statistical analyses, including T-tests and ANOVA, were conducted using software packages such as SPSS, R, and Stata Release 18. These tools were selected based on their robustness and compatibility with the data structure and experimental design. Data analysis examined pre- and post-test data for both groups, employing statistical methods such as T-tests and ANOVA to identify significant performance differences. Furthermore, qualitative data from teacher interviews were thematically analysed to determine the impact of teaching styles in the experimental group on learning outcomes compared to those in the control group. This dual methodology, which combines statistical and thematic research, provides a comprehensive understanding of the effectiveness of teaching strategies. Integrating both types of data ensures a more thorough investigation and enhances the reliability of the results.

4.10.1 Data preparation

Data preparation in research involves cleaning, organising, and coding collected data to ensure accuracy and consistency for analysis (Mackey & Gass, 2021). Creswell and Creswell (2018) supported this by stating that data preparation is crucial for qualitative and quantitative data. It enables researchers to identify patterns and draw meaningful conclusions. Proper data preparation enhances the reliability of findings, facilitating a comprehensive understanding of the research problem (Flick, 2021).

4.10.1.1 Data coding

Data coding involves categorising data and identifying trends (Creswell, 2018). Data from the pre- and post-tests, observations, and interview schedules were all coded to assist with analysis. To ensure confidentiality, the identities of the participants and their schools were replaced with pseudonyms in the teacher questionnaire. Coding was then employed to organise the data into categories or clusters. This coding may be performed manually or with the assistance of computer tools. NVivo 10 was utilised for some of the coding in this study, while manual coding was applied for the remainder. In the research study, data coding was developed to differentiate between the two schools and their learners. School 1, designated as the CG, is represented by the code S1. This school identifies individual learners with the prefix L1, signifying Learner 1 from School 1. Conversely, School 2, which functions as the EG, is assigned the code S2. The learners in this school are similarly coded, with Learner 2 identified as L2**.** This systematic coding facilitates efficient data organisation and analysis, enabling comparisons between the control and experimental groups as the study progresses.

4.10.1.2 Data entry

Descriptive statistics were employed to evaluate learners' overall performance in DH by summarising and analysing results from both pre-test and post-test assessments. These measures helped identify performance trends and group differences. Spaull and Jansen (2024) emphasise the value of such statistics in understanding learning outcomes. This study used descriptive statistics to provide a clear summary of the data prior to inferential analysis. The specific descriptive measures used included the sample size (N), mean, standard deviation, and standard error of the mean for both the experimental and control groups. These statistics helped to describe the central tendency and variability within each group. Additionally, in the context of the paired-samples analysis, descriptive outputs, including paired differences (mean and standard deviation), 95% confidence intervals, and correlation coefficients (with corresponding significance levels), were also examined. These descriptive statistics laid the foundation for interpreting the results of the inferential tests, including T-tests and ANOVA.

4.10.1.3 Missing data

In this study, missing data may occur due to the withdrawal of learners or teachers. However, participants were fully informed of their right to withdraw at any time without affecting their academic performance results. This was communicated through consent forms, which assured participants that their withdrawal would not affect their final marks; instead, they would still acquire DH-related skills. Consequently, any missing data resulting from withdrawal is considered missing at random (MAR), where the likelihood of missing responses is independent of the anticipated values from the withdrawn participants, provided their prior responses are considered. The reasons for withdrawal were documented, ensuring a transparent interpretation of the data. This approach highlights the importance of upholding ethical standards while ensuring missing data does not introduce bias into the study's findings (Zhang & Long, 2021; Lee et al., 2020).

Additionally, it is important to note that in studies involving voluntary participation, the potential for missing data due to participant dropout presents a common challenge. However, when managed appropriately, as seen in this study, the reliability of the results is not detracted. By ensuring participants understood the voluntary nature of the study and its non-impact on their academic standing, the research minimised dropout rates while respecting participants' autonomy. This ethical consideration aligns with best practices in educational research, where both the integrity of the study and the well-being of participants are prioritised. Furthermore, incorporating methods to document reasons for withdrawal and understanding the context of

missing data enriches the interpretation of results, providing a more nuanced understanding of how participant behaviour might affect the outcomes.

4.10.2 Analysis of quantitative data

The quantitative data from the experimental and CGs were analysed. To determine statistically significant differences between the two groups, the researcher employed a T-test with a significance level of 0.05. A T-test is a statistical tool used to compare the means of two groups and determine if the differences are statistically significant. A P-value less than 0.05 indicates a statistically significant difference, resulting in the rejection of the null hypothesis. Contrastingly, a P-value greater than 0.05 indicates no significant difference, thereby supporting the null hypothesis (Field, 2018; Sullivan, 2018). This P-value threshold is often used in research to assess the strength of evidence versus the null hypothesis.

The analysis employed relevant statistical tests, including t-tests and ANOVA, based on the data attributes and experimental design. Analysis of Variance (ANOVA) is a statistical approach used to compare the means of three or more groups and determine whether at least one group's mean differs significantly from the others. Using these approaches, researchers want to determine whether the treatment effects in the EG outperform those in the CG. Following data collection, the researchers used software packages such as SPSS, R, and Strata Release 18 for analysis. Descriptive statistics summarised the data, including means, standard deviations, and sample sizes for both groups.

Effect sizes were calculated to determine the magnitude of the treatment effect, in addition to assessing significance. The goal was to provide a more in-depth explanation of the practical consequences of the findings, beyond their statistical significance. The findings were compared to existing literature, enabling a discussion of the potential mechanisms underlying the observed effects (Cohen et al., 2022; Field, 2023).

4.10.3 Analysis of qualitative data

This study followed Creswell's steps for analysing qualitative data, moving from specific details to broader conclusions and involving multiple levels of analysis (Creswell, 2018:172). The analysis process included open-ended data collected from semi-structured interviews and classroom observations, during which teachers were asked both general and specific questions. The qualitative data were examined using the responses provided by the two teachers before and during the implementation of the intervention strategies. While Figure 4.7 presents a linear, hierarchical progression from bottom to top, the researcher view the process as more dynamic and iterative, with interconnected stages that may not always follow the exact sequence depicted.

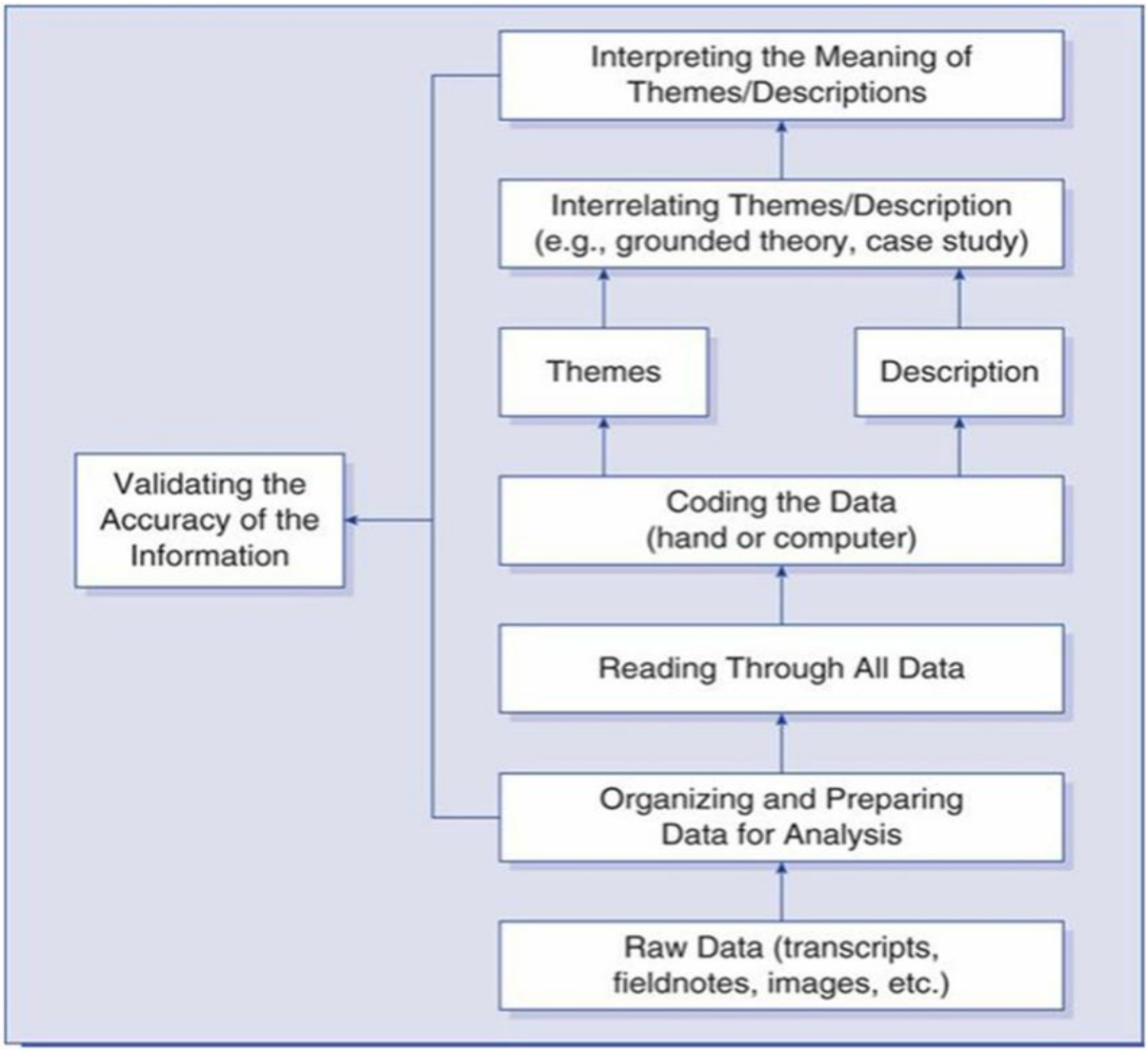


Figure 4.7: ***Data Analysis in Qualitative Research*** (Creswell, 2018:172)

Figure 4.7 illustrates that qualitative research is an iterative process in which raw data are transformed through various stages into coherent themes that uncover deeper meanings (Creswell, 2018). The differing strategies of the two teachers emphasise the importance of pedagogical flexibility and responsiveness to learners' needs in teaching DH concepts. These levels are highlighted in the following steps:

Step 1: Raw Data Collection

The data was gathered through semi-structured interviews with the two teachers, concentrating on six key themes: challenges to learner performance, interaction methods, teaching materials, types of assessment, support for struggling learners, and the creation of a teaching and learning culture. Observations of classroom interactions and subsequent interventions were also recorded.

Step 2: Organising and Preparing Data

The recorded interviews were transcribed verbatim, and notes from classroom observations were compiled. This step ensured that all data was accessible and systematically organised for analysis.

Step 3: Reading Through All Data

The transcribed interviews and observational notes were meticulously reviewed to obtain a comprehensive understanding of the teaching strategies employed by each teacher. This phase involved familiarising myself with the data to gain initial impressions and identify possible patterns.

Step 4: Coding the Data

The data was coded to organise responses and observations into meaningful segments. Codes were generated based on recurring phrases, concepts, and ideas related to each theme. For instance, responses concerning challenges were coded under categories such as "foundational skills," "lack of engagement," and "real-world applications."

Through the coding process, several key themes emerged. These patterns and recurring ideas were identified by carefully analysing the coded data, allowing for a deeper understanding of the underlying trends and insights. The themes reflect the most salient and meaningful aspects of the dataset, providing a structured way to interpret the findings.

Step 5: Identifying Themes:

- ✓ The teacher-learner interaction
- ✓ Learner-learner interaction
- ✓ Teacher-group interaction
- ✓ Group-group interaction
- ✓ Teaching materials
- ✓ Assessment types
- ✓ Culture of learning.

The themes emerged from a rigorous process of thematic analysis, following the six-phase framework (Braun & Clarke, 2006), which includes familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Rather than passively emerging, themes were actively constructed through careful interpretation and iterative engagement with the data. The process was informed by a reflexive approach, acknowledging the researcher's role in shaping the analysis (Braun, Clarke & Terry, 2014). Strategies recommended by Lincoln and Guba were employed to ensure the credibility and trustworthiness of the findings, such as member checking, peer debriefing, and maintaining a detailed audit trail. These measures collectively provide clear

evidence of how the themes were developed, grounded in the data, and established through a qualitative research methodology.

4.11 ETHICAL CONSIDERATION

Prior to the commencement of data collection, the researcher obtained ethical clearance from the University of South Africa (UNISA) through the Faculty/University Ethics Committee, under the South African Research Chairs Initiative (SARChI) ethical approval number 2023/02/08/51908972/27/AM. All ethical principles were strictly adhered to throughout the research process. Written and verbal explanations outlining the study's purpose were provided to all participants before any data collection activities, including testing, began. Participation was entirely voluntary, and informed consent was obtained from all participants. For learners aged 14 to 16 years, who were in Grade 10 during the 2022–2023 academic year, parental or guardian consent was secured in compliance with ethical guidelines for research involving minors. The researcher also reiterated key ethical information upon arriving at each school, ensuring that principals, teachers, and learners were adequately informed and had given their permission, consent, or assent, respectively (see Appendices A, B, C, D1, and D2). The confidentiality of learners' performance in the conceptual knowledge tasks was strictly maintained, and assurances were provided that results would be made available to the schools upon request.

In this study, all participants, teachers and learners, voluntarily participated in the intervention related to DH for Grade 10. Permission was initially obtained from the school principals, who supported the research and facilitated access to the schools. The participating teachers consented freely to engage in the intervention process. The learners, along with their guardians, provided informed consent, being fully aware that participation was voluntary and that they could withdraw at any time without consequence. This ethical approach aligns with current educational research standards, which emphasise the importance of voluntary, informed participation to maintain ethical integrity and foster authentic engagement (Creswell & Guetterman, 2021). In line with quasi-experimental designs, purposive sampling was employed to select participants based on their relevance to the intervention, while still ensuring the voluntary nature of their involvement (Bryman, 2020).

Throughout the study, the researcher adhered to a stringent code of ethical conduct to ensure the protection of participants' rights and well-being. Data were anonymised to maintain confidentiality, and participants were treated with respect, honesty, and transparency. Ethical research involves not only securing informed consent but also fostering an environment of trust and openness, as emphasised by Denzin and Lincoln (2011), who identify 'informed consent' as the cornerstone of ethical inquiry, requiring both comprehension and voluntary

agreement. Similarly, Bhandari (2021) and Webster (2022) emphasise the importance of integrity, non-discrimination, bias avoidance, and accountability in the ethical management of research data. The ethical rigor upheld in this study contributed to the reliability and validity of the research process. By aligning with these scholarly standards, the study ensured its ethical credibility and the responsible treatment of all participants.

4.11.1 Ethical Considerations and Data Management

This study adhered to the university's ethical research guidelines and nsured that participant rights, privacy, and confidentiality were upheld. Informed consent was obtained. All data, including assessments and interviews, was stored on encrypted, password-protected devices. Access was restricted to authorised researchers only. Following institutional policy, data will be retained for five years and then permanently deleted or destroyed (Creswell & Creswell, 2018; Babbie, 2020)

4.11.2 Data Storage, Security and Retention

The researcher complied with UNISA's research ethics guidelines by ensuring that all collected data, including learners' marks from pre- and post-tests, and interview recordings, were stored and managed securely. The learners' assessment data was stored in password-protected digital files on encrypted devices and/or secure institutional servers, with access limited to authorised research personnel. Adhering to the same security protocols, interview recordings from pre-interviews with teachers and the post-interview with one teacher are also stored in encrypted digital formats.

In line with UNISA policy, all data will be retained for a minimum of five years after the completion of the study to allow for verification or auditing if necessary (UNISA, 2021). After this period, the data will be securely destroyed. Digital files will be permanently deleted using certified data erasure software, and physical documents will be shredded and disposed of in accordance with applicable regulations (Creswell & Creswell, 2018; Babbie, 2020). The (ibid) emphasises the importance of ethical data handling and secure data management to maintain research integrity and protect participants' confidentiality. By adhering to these procedures, the researcher ensured that the research complied with both institutional and international ethical standards.

Furthermore, Leedy and Ormrod (2019) emphasise that safeguarding participant information is not only an ethical imperative but also crucial to maintaining public trust in academic research. McMillan and Schumacher (2014) highlight that ethical transparency and secure data storage are essential for the credibility and replicability of findings. Similarly, Cohen,

Manion, and Morrison (2018) assert that careful data stewardship reinforces respect for participants' rights and upholds the researcher's moral responsibility.

4.12 CHAPTER SUMMARY

This chapter detailed the research methodology of the study, which employed a concurrent mixed-methods design to address the research questions. By integrating quantitative and qualitative approaches, the study captured both measurable learning outcomes and nuanced contextual insights. The quantitative phase utilised pre- and post-tests to assess learners' understanding of DH concepts, providing objective data on knowledge acquisition. Meanwhile, the qualitative phase involved conducting teacher interviews and classroom observations, which provided insights into instructional strategies, challenges, and learner engagement. The combination of these methods enabled triangulation, strengthening the validity and reliability of the findings.

The chapter also justified the chosen methodology, demonstrating how the mixed-methods approach facilitated a rigorous and holistic examination of the research problem. By merging data-driven analysis with interpretive insights, the study effectively explored the complexities of teaching and learning DH while maintaining alignment with its objectives. Chapter 5 presents and discusses the findings derived from this methodological framework.

CHAPTER FIVE: PRESENTATION, ANALYSIS AND INTERPRETATION OF THE FINDINGS

5.1 INTRODUCTION

Chapter Four provided a comprehensive overview of the research methodology employed in this study, including the paradigm, strategy, design, data collection methods, and data analysis procedures. This chapter analyses the quantitative and qualitative data acquired through pre-tests, post-tests, lesson observations, and interviews. This chapter is structured into six essential components, encompassing the analysis of pre-test results, observations, and interviews conducted during the lessons, post-test findings and statistical analysis.

The aim of this study was to investigate the effectiveness of teaching strategies for Grade 10 Data Handling. The research sought to address the following questions.

RQ1: How do teachers teach Data Handling to Grade 10 learners?
RQ2: What challenges do teachers encounter when teaching Data Handling practices?
RQ3: What strategies can teachers employ in Grade 10 to effectively teach Data Handling?

The study also evaluated the hypotheses that:

H_0: *The application of Strategies does not affect the performance of DH Grade 10 learners.*

H_1: *The application of Strategies does affect the performance of DH Grade 10 learners.*

5.2 ANALYSIS OF THE PILOT STUDY

The researcher conducted a pilot study by administering the pre-test before the main study. The pre-test in this study comprised six questions, totalling 50 marks. The findings from the pilot study indicated that the test required modification and adjustment. The examination was initially set for 40 minutes; however, most learners were unable to complete it in this timeframe, with many finishing instead in 60 minutes. Consequently, the researcher extended the duration of the writing test to 60 minutes. Additionally, the research noted that the numbering of questions was duplicated, appearing as 1.3 and 1.3 again, and the total marks exceeded 50; therefore, these instances were removed from the paper. The pilot study involved high school mathematics learners who expressed a willingness to participate but ultimately did not participate in the main study. All participants had studied DH in Grade 10. According to Turner et al. (2022) and Dikko (2023), reporting the outcomes and adaptations from pilot studies enhances the transparency, credibility, and methodological rigor of educational research, especially when refining instruments for data quality and relevance.

5.3 PRE-TEST RESULTS QUANTITATIVE ANALYSIS

The study involved 60 Grade 10 learners from two selected public schools in the Bojanala District of South Africa's Northwest Province, within the Bonesang circuit. The EG consisted of 30 learners from Kurisani Secondary School (a pseudonym) and T2, while the CG included 30 learners from Andzani Secondary School (also a pseudonym) and T1. Participants ranged in age from 13 to 16 years.

The study employed pre-tests and post-tests to assess the success of the intervention, yielding essential quantitative data on changes in learners' skills and knowledge in DH. This approach facilitated a comparison between the two groups, aiding in the evaluation of the intervention's impact on enhancing learners' comprehension of DH in mathematics. Analysing the outcomes of the preliminary and concluding assessments of the primary study served as a crucial method for evaluating the efficacy of the intervention, providing quantitative data that highlighted changes in learners' skills and knowledge related to DH. The pre-test served as a benchmark to assess the impact of the instructional technique on learner achievement. Analysis of the results from the initial and final tests of the main study was a key method for assessing the effectiveness of the intervention, offering quantitative data that highlighted changes in learners' skills and knowledge pertaining to DH. The pre-test functioned as a baseline to evaluate the effect of the teaching strategy on learner achievement. Analysis of the pre-test results from a quantitative perspective, as presented in Tables 5.1 to 5.6, illustrates learners' performance in both the EG and the CG across Questions 1 to 6 (see Appendix S). The researcher personally administered the pre-test in both schools, ensuring consistency in the process by coordinating with the teachers.

The collected data were categorised according to predefined codes to enhance understanding of the overall performance of the experimental and control groups in the pre-test. The percentages for each category were calculated based on the number of learners. A quantitative analysis of the learners' responses was conducted to identify the challenges that contributed to their poor performance. Furthermore, Warren (2022:97) affirmed that quantitative data analysis entails categorising numerical data through various statistical methods. The pre-test was administered to evaluate the performance of Grade 10 learners in DH prior to the intervention.

The diagnostic test employed in this study consisted of six questions, each with associated sub-questions, organised into three pairs (Q1 with Q2, Q3 with Q4, and Q5 with Q6) based on thematic similarity to enhance coherence in presentation. Learner performance was evaluated using four distinct response categories: Correct Responses (CR), Incorrect Responses (IR), Incomplete Responses (IRs), and No Responses (NR). The frequencies for each category are

presented in a summary table. In addition to formal participant withdrawal, it was observed that some learners left individual questions either responses or partially responses. For analytical consistency and validity, these four categories were applied uniformly across all responses. To ensure the integrity and validity of study findings, it is critical to thoroughly document the reasons for participant withdrawal during follow-up procedures. This practice allows researchers to assess potential biases, evaluate the impact of attrition on results, and enhance the transparency of the study (Cragg et al., 2024).

- ✓ A Correct Responses (CR) indicates that the learner successfully applied the correct procedures or formulas.
- ✓ An Incorrect Response (IR) occurs when the learner attempts the problem but fails to arrive at the correct answer.
- ✓ Incomplete Responses (IRs) are when learners attempt the question but cannot fully complete it, often due to perceived difficulty (Fritz et al., 2019).
- ✓ No Responses (NR) indicates that the learner left the question blank without making any attempt.

These categories provide insight into the learners' varying levels of engagement and understanding.

5.3.1 Learner responses to Q1 and Q2 items

The Q1 and Q2 assessments concentrated on the three most commonly used measures of central tendency: mode, median, and mean. In Question 1.1, learners were assessed on their understanding of these three measures: mode, median, and mean.

Table 5.1: ***Distribution of learners' responses in Q1 and Q2***

QUESTIONS	ROUPS	PRE-TEST							
		Number of learners & 'Percentage (%)' performed							
		CR		IR		IRs		NR	
Q1	Experimental	6	20%	7	23%	10	33%	7	23%
	Control	3	10%	11	37%	7	23%	9	30%
Q2	Experimental	7	23%	6	20%	11	37%	6	20%
	Control	8	27%	10	33%	11	37%	1	3%
TOTAL	Experimental	13	43%	13	43%	21	70%	13	43%
	Control	11	37%	21	70%	18	60%	10	33%

The findings in Table 5.1 reveal notable differences in performance between the EG and the CG on directed hypothesis DH tasks for Questions 1 and 2. In Question 1, only 20% of learners in the EG respond correctly (CR), compared to a lower success rate in CG, which obtained 10% in CR. This suggests that the EG had a better understanding of concepts related to measures of central tendency, although overall achievement in both groups remained poor. The EG showed a slight improvement in Question 2, with 23% of learners answering correctly, while the CG experienced a more substantial increase, rising by 17% to reach a total of 27% correct answers.

Despite these improvements, the majority of learners in both groups continued to struggle with understanding fundamental DH concepts. In the EG, 70% of learners were unable to solve the problem, and only 20% provided correct answers (CR), indicating that most learners, even with the intervention, did not fully comprehend the material. The remaining learners in the EG exhibited varying levels of engagement: 23% showed some interest but still struggled with the calculations (IR), 33% demonstrated a lack of understanding (IRs), and 23% did not attempt the questions at all (NR). In comparison, the CG performed even worse, with only 10% of learners answering correctly and 90% struggling with the task. Among these, 27% showed some effort but were still incorrect, 33% demonstrated a lack of understanding, and 30% did not attempt the questions at all.

Overall, although the EG outperformed the CG with 43% correct responses compared to 37%, both groups encountered significant challenges with fundamental DH tasks, such as calculating the five-number summary and identifying maximum and minimum values. Despite the intervention in the EG, many learners continued to struggle with these essential concepts, indicating that further instructional strategies may be necessary to enhance understanding. The findings emphasise the importance of ongoing support and targeted teaching methods to improve learners' comprehension of DH and statistical concepts.

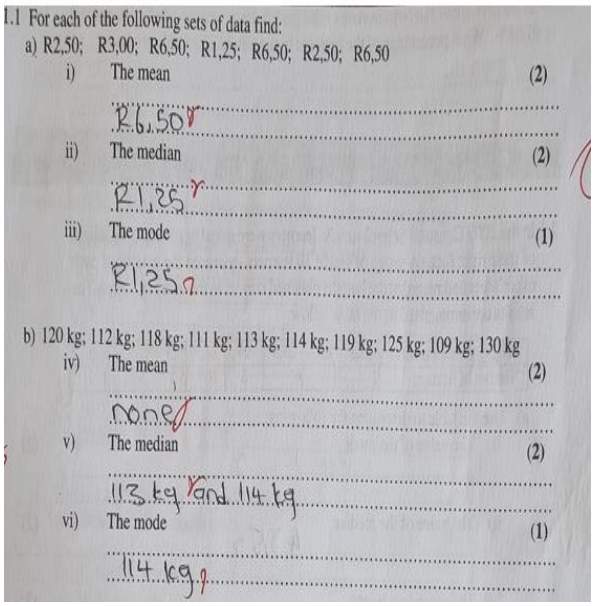
The following samples were taken from two learners who responded to Question 1, namely, L13 and L14.

Question 1

Figure 5.1 of the learner’s response when completing the measures of central tendency are the mode, median, and mean.

Figure 5.1 of Incorrect responses from L13 & L14

L13



L14

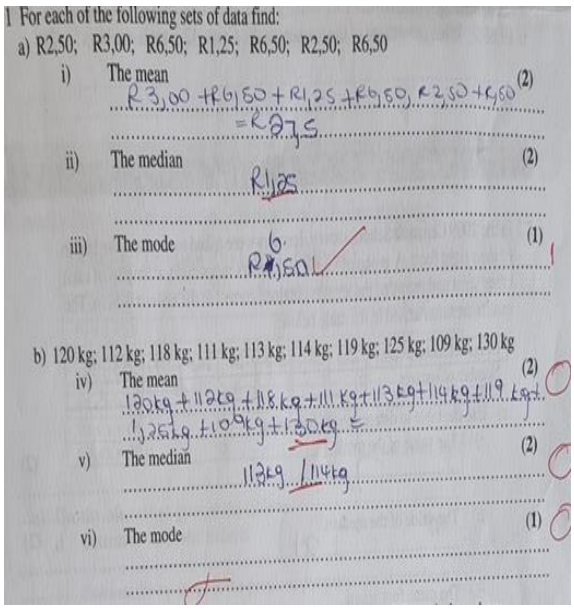


Figure 5.1 highlights significant challenges that Grade 10 learners, L13 and L14, face in applying DH concepts, such as the mean, median, and mode, despite having been taught these topics in earlier grades. According to Vygotsky (1978), learners at the "actual level" should be capable of utilising their prior knowledge to solve mathematical problems. However, both learners struggled with calculating the mean, with L13 confusing it with the mode and failing to apply the correct formula. This indicates a gap in their conceptual understanding and ability to apply mathematical principles despite previous exposure to these concepts in earlier grades.

In addition to their struggles with the mean, both learners had difficulty calculating the median. They mistakenly believed that the middle value could be determined without first sorting the data in ascending order. This misconception further illustrates the importance of teaching procedural knowledge and ensuring that learners understand the steps involved in calculating the median. Likewise, although L14 correctly identified the mode, both learners made mistakes in calculating it, such as confusing the mean with the mode or misadding numbers. The DBE's (2023) diagnostic report highlights the importance of teaching statistical concepts to emphasise the meaning behind these concepts rather than simply the mechanics of calculation.

Learners' difficulties underscore the broader challenges of teaching statistics, where a balance between calculations and conceptual understanding is essential. The DBE (2020) advocates for extensive practice and a deeper comprehension of statistical procedures rather than relying

on memorisation. In addition to teaching the steps involved in calculating statistical measures, teachers must assist learners in connecting these measures to real-world applications. As the DBE (2023) indicates, this approach enable learners to appreciate the value of statistical concepts better and apply them effectively in real-life contexts, leading to a more comprehensive understanding of statistics.

5.3.2 Learner responses from Q3 and Q4 items

In Question 3 of 3.1, learners were assessed using grouped data to calculate the mode, mean, and median based on data previously presented in interval form. Meanwhile, in Question 4, learners were evaluated on measures of central tendency. Although this involved another data set, this time, they were given the solution of the five-number summary, and then they needed to identify the errors through their calculations. The data provided was well organised.

Table 5.2: ***Distribution of learners' responses to Q3 and Q4***

QUESTIONS	**GROUPS**	**PRE-TEST**							
		Number of learners & 'Percentage (%)' performed							
		CR		**IR**		IRs		**NR**	
Q3	Experimental	3	10%	7	23%	9	30%	11	37%
	Control	1	3%	11	37%	10	33%	8	27%
Q4	Experimental	5	17%	3	10%	10	33%	12	40%
	Control	2	17%	6	10%	10	33%	12	40%
TOTAL	Experimental	8	27%	10	33%	19	63%	23	77%
	Control	3	20%	17	47%	20	66%	20	67%

The DH assessment results reveal significant disparities in the performance of the EG and CG. Both groups scored poorly in their CR, with the EG achieving scores between 10% and 17% and the CG ranging from 3% to 17%. These low scores reflect a limited understanding of DH, as the corresponding IR results indicate. The IRs scores highlight a notable gap in conceptual understanding and the proficiency required to perform DH procedures effectively.

Further analysis indicates that the CG performed worse than the EG, particularly on questions related to measures of central tendency. The highest CR score for the CG was 30%, whereas the EG's highest score was slightly higher at 34%. Questions 3 and 4, which assessed understanding of these measures, were complex, and the overall CR scores further reflected the CG's lower performance, with the EG achieving an average score of 32.7% compared to the CG's 22.1%. The Performance Assessment results demonstrated some improvement in

the EG, which scored 27.3%, while the CG scored 20.6%, underscoring the EG's superior performance.

Despite these differences, both groups struggled with interpreting and analysing grouped data, particularly when calculating measures of central tendency for data organised in interval form. The IR scores were higher for the CG at 57.3% compared to the EG at 40.0%, indicating that while the EG performed better overall, both groups faced significant challenges in understanding the procedural and conceptual aspects of handling grouped data. In conclusion, although the EG showed some improvement, both groups require further intervention and targeted support to enhance their understanding of key statistical concepts and procedures, especially those related to grouped data analysis.

5.3.3 Learner responses to Q5 and Q6 items

Question 5 comprised two items, while Question 6 consisted of six items. In Question 5, particularly in 5.1, learners were evaluated on their understanding of five-number summaries and on constructing box and whisker diagrams from the provided disorganised data. The question was based on the five-number summary calculated by the learners, prompting them to create a box-and-whisker diagram using their solutions. Meanwhile, in Question 6, learners were assessed on scatter plots. Six scatter plot graphs were pre-drawn, and learners needed to identify the relationship of each graph with the given terms, including no correlation, a strong negative relationship, a strong positive relationship, a moderate negative relationship, a moderate positive relationship, and a non-linear relationship.

Table 5.3: ***Distribution of learners' responses to Q5 and Q6***

QUESTIONS	**GROUPS**	**PRE-TEST**							
		Number of learners & 'Percentage (%)' performed							
		CR		**IR**		IRs		**NR**	
Q5	Experimental	9	30%	1	3%	15	50%	5	17%
	Control	5	17%	6	20%	15	50%	4	13%
Q6	Experimental	6	20%	1	3%	12	40%	11	37%
	Control	3	10%	10	33%	12	40%	5	17%
TOTAL	Experimental	15	50%	2	6%	27	90%	16	54%
	Control	8	27%	16	53%	27	90%	9	30%

The results presented in the table reveal significant differences in the performance of the EG and CG on DH tasks. The EG demonstrated higher capability assessment (CR) scores, ranging from 30% to 20%, while the CG's scores were lower, between 17% and 10%. Both groups displayed competence in managing data for Question 5 (Q5). However, the CG

performed poorly compared to the EG on tasks related to the five-number summary, particularly in Q5 and Q6, which required drawing the box-and-whisker plots. These results indicate that the EG better understood the statistical concepts necessary for constructing these plots.

Further analysis of the performance data revealed that the CG achieved a CR score of 27%, while the EG achieved a higher score of 50%. In Q5, 30% of EG learners successfully identified the most significant and smallest numbers correctly, compared to only 17% of CG learners. Despite this, both groups struggled to interpret and analyse the numbers in the context of box-and-whisker plots. Only 3% of EG and 20% of CG learners were able to correctly interpret and analyse the data in the written assessment. This indicates a significant gap in both groups' ability to apply their knowledge to interpret graphical representations of data.

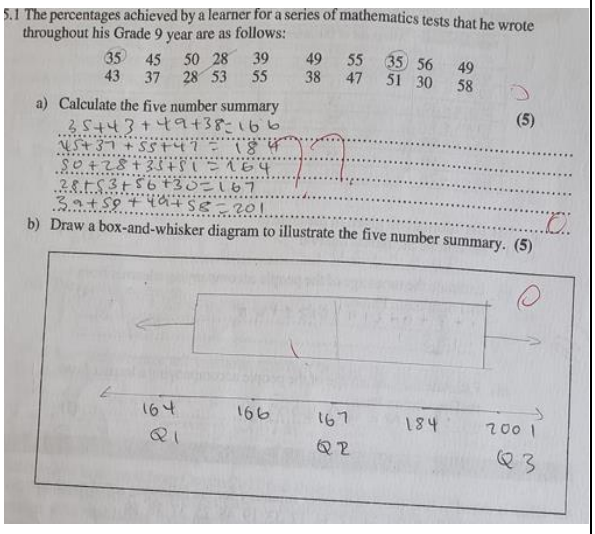
Moreover, while the EG outperformed the CG in overall DH tasks related to the five-number summary, both groups displayed significant weaknesses in data interpretation and analysis. These findings highlight the need for improved instructional support, particularly in helping learners develop a deeper understanding of DH concepts. The results also highlight the importance of targeted teaching strategies and scaffolded learning in improving learners' comprehension and skills in statistical analysis.

The following samples were collected from two learners who responded to Question 5, namely, L20 and L21.

Figure 5.2 of learners' response to drawing a box-whisker diagram.

Figure 5.2 Incorrect respond from L20 & L21

L20



L21

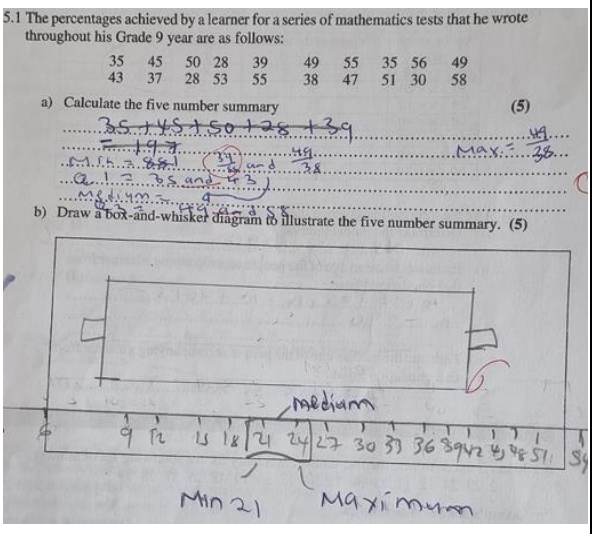


Figure 5.2 highlights that learners L20 and L21 faced challenges in answering Question 5, which required them to calculate the five-number summary and draw a box-and-whisker plot. Although both learners demonstrated a fundamental understanding of the shape of the box plot, they struggled with calculating the five-number summary, which is essential for creating an accurate box plot. The five-number summary, comprising the minimum, first quartile (Q1), median (Q2), third quartile (Q3), and maximum, is crucial for constructing box plots. Without this understanding, the learners were unable to complete the task correctly. This illustrates a broader issue within statistical education: learners often struggle to apply foundational concepts to more complex tasks.

The challenges faced by L20 and L21 align with findings from the Department of Basic Education (DBE, 2022:198), which noted that many learners struggle to input data accurately into calculators, resulting in errors when calculating the five-number summary. This issue has compounded their difficulties in drawing box plots, which require precise data analysis and calculation. The confusion surrounding statistical terminology, particularly regarding the term "five-number summary," has further contributed to their struggles. The DBE (2023:198) emphasised the importance of frequent exposure to and use of statistical terms in the classroom, which can enhance learners' understanding of these concepts and reduce confusion in assessments.

In part (b) of the question, the learners' inability to calculate the five-number summary directly affected their capacity to connect it to the box-and-whisker plot. Had they been provided with the summary values beforehand, they might have succeeded in drawing the box plot. This indicates that their challenge lay not in comprehending the graphical representation but in calculating the underlying statistics. Conversely, learners L24 and L26, who performed better on Question 6, demonstrated how understanding the five-number summary can aid in accurately drawing a box-and-whisker plot. This emphasises the significance of strengthening foundational statistical knowledge to support more complex data analysis tasks (Sharma & Verma, 2017; DBE, 2023:198).

Question 6

Figure 5.3 of learners' responses on describing the relationship from the scatter plot

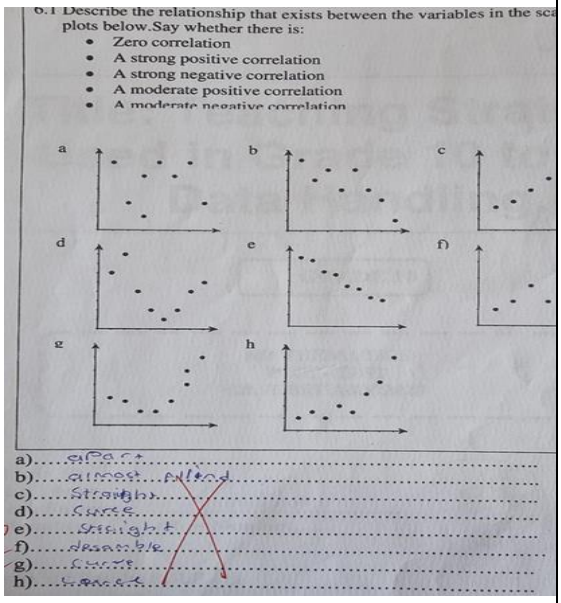
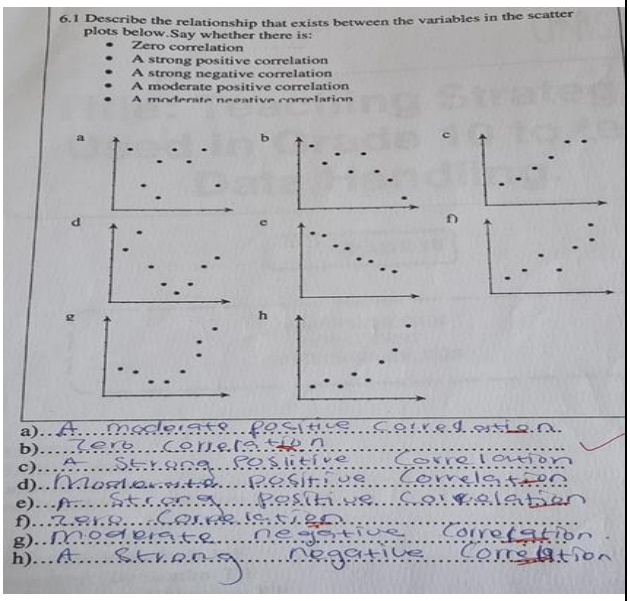
Figure 5.3 to Incorrect respond by L24 & L26	
L24	L26
	

Figure 5.3 highlights the difficulties encountered by learners L24 and L26 in identifying and interpreting scatter plots, a key aspect of DH. Although they understood the fundamental concept of reading a graph from left to right, both learners struggled to describe or interpret the trends in scatter plots, such as recognising whether they were increasing (positive) or decreasing (negative). Jonhera (2018:7) notes that many pupils struggle to interpret data presented in compound and stacked bar graphs and scatter plots, especially when multiple data sets are involved. This issue often stems from a lack of prior knowledge, which leads to conceptual errors and subsequently results in procedural mistakes. DBE (2022) also reported that during the NSC mathematics examination, many learners lacked understanding of DH, especially concerning graph interpretation.

Fong (2021:1) emphasises the importance of learning DH to understand graphing, a crucial aspect of statistics. Nevertheless, an ongoing debate exists regarding whether learners should be taught to create graphs or to interpret them first. Ergül (2018:139-140) highlights that DH, encompassing the visual representation of data through suitable graphs, is vital for statistical comprehension. The DBE (2016) further highlighted that many learners struggled to create and interpret graphs, particularly histograms, during the 2016 National Senior Certificate (NSC) mathematics examination. This issue was compounded by their difficulty in distinguishing between occurrences and increasing frequencies, further highlighting the pervasive gaps in understanding DH and graphing among learners.

5.4 PRE-INTERVENTION SEMI-STRUCTURED INTERVIEW

As outlined in Chapter 4, structured interviews and lesson observations were conducted with two teachers from different groups: experimental and control, immediately after the pre-test and prior to implementing the identified teaching strategies for the EG. These interviews aimed to gather insights into the teachers' interpretations of the pre-test results, concentrating on learners' strengths and weaknesses in daily living DH skills. The teachers also discussed the effectiveness of their current instructional strategies and identified areas where learners encountered difficulties, which subsequently informed the design of the intervention. The qualitative data gathered from these interviews were crucial for tailoring support to enhance learner outcomes. This approach aligns with Creswell (2023), emphasising the significance of understanding teachers' perspectives and the educational context to inform practice and improve learning outcomes. The interviews were analysed using semi-structured formats, with participants designated as Teacher 1 (T1) and Teacher 2 (T2).

5.4.1 Analysis of structured interviews with teachers following the administration of the Pre-Test

The following excerpts from teachers are presented as examples. By capturing the perspectives and experiences of teachers, this analysis provides deeper insight into the educational environment, emphasising the value of qualitative methods in educational research (Teddlie & Tashakkori, 2022). The teachers from both the EG and CG were asked the following questions:

The two teachers were asked the following questions, categorised as indicated in italics:

Challenges in DH: *1. What do you think could contribute to the poor performance of the learning concept of DH, and why?*

Classroom Interaction: *2. How do you engage with your learners during the teaching and learning of DH?*

Teaching and Learning Materials: *3. What materials do you use when teaching DH?*

Classroom Assessment: *4. What assessment do you use in the DH classroom?*

Learner Support in Mathematics: *5. What kind of support do you provide to struggling learners?*

Classroom Culture: *6. How do you foster a culture of teaching and learning in your DH classroom?*

A few excerpts from the DH teachers' interviews are presented below as examples. The transcripts are provided verbatim without any edits.

Transcript 1: *What do you think could contribute to the poor performance of learners in the concept of DH?*

Excerpt 5.1
The following illustrates the teacher's responses to the interview questions in Transcript 1

Teacher 1 *The learners enter Grade 10 without prior knowledge of DH from previous grades. They are unable to identify the five-number summary in DH, which they should have learned in Grade 9. Additionally, some learners lack seriousness in the classroom, such as not completing homework. Our school has a high number of orphaned learners, and when we seek support from their guardians, we often do not receive sufficient assistance, as many of the guardians are uneducated and unable to help their children with homework. The community in which our school is located also impacts learner performance, as most parents do not engage in their children's learning.*

Teacher 2 *Some learners struggle with basic tasks in DH, such as calculating the range, which only requires Max then Subtraction Min. This remains a challenge for them. Some express that they don't enjoy mathematics, but they remain in the subject because their guardians want them to pursue careers as doctors, engineers, pilots, etc. Only a few learners perform well in DH, while the majority of the class consists of learners who struggle with the subject. Some of this difficulty stems from a lack of effort, as mathematics requires significant dedication, passion, energy, and time, which many learners are not willing to invest.*

In Excerpt 5.1, both teachers highlight critical issues regarding learners' lack of prior knowledge and engagement in mathematics, particularly in DH. As stated by both teachers, this deficiency in background knowledge and commitment to the subject poses a significant barrier to their success. This aligns with Bandura (1986:210), that motivation and self-efficacy are critical determinants of academic success. From the researcher's perspective, these findings suggest that beyond instructional strategies, it is equally important to nurture learners' confidence and sense of agency in mathematics. Observing learners during the intervention, I noticed that those who believed in their ability to solve problems, regardless of their initial accuracy, persisted longer and engaged more meaningfully with the material. This reinforces the researcher's belief that effective teaching must address cognitive development and intentionally build learners' self-efficacy to foster sustained engagement and resilience in mathematical learning. Furthermore, Foreman and Arthur (2017:19) argue that teaching must address both academic needs and the social and emotional factors that impact learner engagement. The challenges noted by Teacher 1 and Teacher 2, such as the lack of prior knowledge.

Transcript 2:

How do you engage with your learners during the teaching and learning of DH?

Excerpt 5.2

Teacher 1 *Learners often lose interest in DH quickly. Despite making extra efforts to attend lessons in the morning and afternoon, they tend to leave spaces blank when faced with difficult problems. When marking their work, it often appears incomplete. When asked about their unfinished solutions, some learners simply say the task is too difficult. Additionally, some learners stay at school after hours to study since they do not have a conducive environment to work at home. However, even during lessons, they do not pay attention or engage with the material.*

Teacher 2 *To begin the lessons we usually start with the corrections of the previous like homework corrections, they will show the expression of understanding. When you check their scores on the class work book they didn't get it. After explaining the solution then you ask if they do understand they always say "yes we understand" but when you test them they don't managed.*

In Excerpt 5.2, both Teacher 1 and Teacher 2 describe the challenges they encounter in engaging learners during the teaching of DH, particularly with those who struggle to maintain interest or commitment to their schoolwork. Both teachers rely heavily on traditional teaching methods, such as correcting homework and providing direct explanations, which may not be sufficient to foster meaningful engagement or to address learners' lack of foundational knowledge in DH. Learners' difficulties in understanding basic concepts, such as mean, range, and median, suggest a need for more interactive and learner-centred instructional approaches. The researcher suggests that both teachers could benefit from incorporating more collaborative learning techniques, PS activities, and formative assessments that provide real-time feedback.

Transcript 3: *What teaching materials do you use when teaching DH?*

Excerpt 5.3

Teacher 1 *I rely on a textbook and study guide to teach DH, as our school does not have enough resources. I have instructed the learners to share a textbook, with two learners using each one.*

Teacher 2 *I use previous question paper for them to practice, although textbook is not enough for them to refer at home. Sharing a textbook is difficult if one learner*

takes the text book and the tomorrow is absent the other learner will have the book, also the book gets lost easily.

In Excerpt 5.3, both Teacher 1 and Teacher 2 highlight the significant challenge of limited resources, particularly textbooks, which directly impact their ability to teach DH effectively. Both emphasise how the shortage of textbooks creates barriers to effective learning, limiting learners' access to essential study materials. This aligns with Adams (2006), who argues that access to adequate learning resources is crucial for supporting learner achievement, particularly in subjects like mathematics. Higgins et al. (2012) also emphasise that insufficient educational resources can exacerbate inequalities in learning, making it more challenging for learners to engage with and master complex concepts like DH. Therefore, the lack of textbooks, as highlighted in the interview, not only impedes learners' ability to complete homework and assignments but also undermines the effectiveness of the teaching process itself. The researcher may call for increased resource investment to ensure equitable access to materials that support learning.

Transcript 4: What type of assessment do you use in the DH classroom? Why do you believe classroom assessment is important in teaching mathematics?

Excerpt 5.4

Teacher 1 *DBE provides with ATP (Annual Teaching Plan) which shows the work to be done for the whole year in mathematics. Our ATP consists of daily programme to be taught also classwork and home work must be daily. The assessment is set according to what is covered on the ATP. We usually receive every assessment like investigations, assignments, research, standardised tests and examinations. The only assessment that we set is the informal ones like homework and classwork.*

Why?

I realised that learners need to work at a level appropriate for their current abilities in order to accelerate their progress, build on their strengths, and address any gaps in their understanding. The teachers then discussed how to proceed, with one teacher working with the group that understanded the concepts well, allowing them to move ahead. Another teacher focused on consolidating the concepts with a different group, while the third teacher supported learners who needed help reaching the concepts. Ultimately, all learners took the same test, as our school requires standardised assessments.

Teacher 2 *We got the direction from department where every assessment is set according to what is covered on the ATP.*

Why?

To determine what skills learners have and understanded in DH. I am able to gauge how well learners have understood the concepts I've taught and identify ways to support the slower learners.

In Excerpt 5.4, both Teacher 1 and Teacher 2 emphasise the significance of assessment in teaching DH, acknowledging that evaluations are essential for identifying learners' strengths and areas needing improvement. They recognise that assessments enable them to reflect on their teaching and adapt strategies to enhance learner performance. However, they point out that more structured collaboration could benefit the assessment process. The researcher's perspective indicates that although both teachers utilise assessment for reflection, there is a need for more formal opportunities for collaborative data analysis and reflection rather than relying solely on individual efforts. This would enable the sharing of insights and collectively address learning challenges. Hattie (2009) and Black & Wiliam (2009) highlight the importance of formative assessments and teacher collaboration in fostering improvement in learner outcomes, suggesting that collaborative analysis of assessment data could enhance teaching practices and learner results.

Transcript 5:

What kind of support do you provide to learners who are struggling?

Excerpt 5.

Teacher 1 *As a teacher intervene with the parents or guardians to meet to discuss the issue. The intervention usually becomes successful because the teacher will request the parents to advise their children to do their work at home under their supervision as a parent. Also at school I will also make sure that I put pressure on the learner.*

Teacher 2 *I will give extra work to those who are not performing well and remain with them and leave the other ones who understand the concept. However the challenge is that the smarter ones will be mocking those who attended calling them the names.*

In Excerpt 5.5, both Teacher 1 and Teacher 2 are committed to supporting learners who face developmental challenges by providing targeted interventions to enhance their performance. Teacher 1 engages parents in the process by organising meetings to discuss the learner's difficulties and requesting parental supervision of homework, while also applying pressure at school to encourage responsibility. Teacher 2 provides additional work to struggling learners

and offers individualised support, allowing more proficient learners to continue progressing. While these strategies align with Vygotsky's (1978) concept of scaffolding, which posits that learners receive tailored support to achieve a deeper understanding, Hattie (2009) emphasises the significance of feedback and intervention in promoting academic success. However, Teacher 2's challenge concerning learner ridicule indicates a need to cultivate a more inclusive classroom environment, as suggested by Cohen (1992), who emphasises the significance of respect and peer support in ensuring all learners feel safe and encouraged. The research highlights that while these interventions are valuable, effectively managing classroom dynamics and promoting a culture of inclusivity is crucial for the success of such support strategies.

Transcript 6: How do you foster a culture of teaching and learning in your DH classroom?

Excerpt 5.

Teacher 1	*As a subject teacher I need good environment in my classroom like classrooms with rules, discipline learners also good hygiene class.*
Teacher 2	*I make class rules and expect my learners to follow them then award those who are following the rules and punish those who disobey the class rules.*

Excerpt 5.6 illustrates that both teachers can establish order and cultivate a positive classroom environment. In addition to structure, Cohen (1992:10) argues that nurturing a culture of mutual respect within the classroom is equally crucial. Teachers should promote learner support and respect for one another, fostering a learning atmosphere where communication and constructive conflict resolution are prioritised. The emphasis by Teacher 1 and Teacher 2 on rules and discipline aligns with Calman (2010:9) and Shulman (2010:9), who assert that a well-ordered environment is essential for learning. However, as Cohen emphasises, fostering learner relationships may require enhancement. By integrating opportunities for learners to communicate and address differences constructively, teachers can further reinforce the classroom culture and ensure that no learner feels intimidated or excluded, thereby promoting a more inclusive and supportive learning environment. This reinforces the idea that a robust classroom culture is not solely defined by rules but also by how teachers actively facilitate positive interactions and engagement among learners.

5.4.2 Baseline lesson observations after pre-test

As previously mentioned, the researcher conducted classroom observations to gain insight into the teachers' instructional methods. DH. EG T2's lesson focused on calculating the five-number summary and drawing scatterplots from disorganised data, starting with sorting values in ascending order. Meanwhile, T1's CG covered how to calculate mode, mean, median, and

range. Danielson (2022) emphasises that such observations can significantly enhance teachers' pedagogical skills by facilitating constructive feedback and supporting professional growth. The observations revealed five key themes that emerged during this process, primarily concentrating on areas of concern.

5.4.2.1 Teaching Strategies

T2's lesson on the five-number summary addressed homework corrections and encouraged learner participation through chalkboard activities. However, the lesson revealed a lack of genuine engagement, as many learners merely copied the corrections without critically engaging with the material. This behaviour reflects a dependence on rote learning rather than critical thinking (Khan & Lee, 2023). The (ibid) argue that external validation, rather than authentic understanding, often hinders learners from developing PS skills independently.

Despite the challenges, T2's lesson aimed to foster collaboration and mathematical skills through hands-on activities such as organising data and creating scatter plots. However, opportunities for collaboration were overlooked, resulting in a competitive, self-centred atmosphere. Robinson and Green (2024) emphasise that fostering independent learning and critical thinking is vital, particularly when learners lack external support. This disconnect from collaborative learning hindered deeper engagement with the lesson. In contrast, T1's lesson began with corrections, followed by written and verbal feedback; however, this approach also failed to promote meaningful learner participation. Although efficient, the method did not address learners' underlying struggles, as they continued to copy answers without understanding their mistakes. Weimer (2021) emphasises that active participation and ownership are essential for effective learning, which were lacking in T1's classroom and contributed to the disengagement.

A lack of collaborative learning and learner engagement hindered T1's focus on foundational DH skills using decimal data. Danielson (2022) emphasises the importance of reflective practice in enhancing instructional strategies and improving learner outcomes. T1's traditional, less interactive approach missed the opportunity to foster a more dynamic and supportive learning environment, limiting the lesson's overall effectiveness.

5.4.2.2 Learner involvement

Active learner participation in teaching and learning is essential for fostering a deeper understanding of concepts, as demonstrated by T2's approach to teaching DH. T2 actively engaged all learners, not just those who raised their hands, ensuring that even quieter learners had opportunities to participate. For example, she invited a learner to the chalkboard to reorganise data in ascending order. To clarify the difference between ascending and descending, T2 creatively used a staircase analogy, illustrating that "ascending" means

moving upward and "descending" means moving downward. This approach clarified the concept and utilised visual aids, such as number cards and charts, fostering a more inclusive and engaging learning environment.

In contrast, T1's method of focusing primarily on learners who raised their hands limited participation and may have left some learners feeling overlooked or disengaged. Hall et al. (2012) highlighted that effective teaching involves discovering ways to inspire all learners and bolster their confidence in mathematics. To enhance learner involvement, teachers must be well versed in strategies that promote engagement and understanding (Shulman, 1986; Koponen et al., 2017).

5.4.2.3 Teaching and learning resources

T1 effectively used number charts to teach number sequencing by helping learners identify which numbers precede the given data. She provided each learner with small cards that allowed them to physically arrange the numbers. This practical approach, combined with a larger chart displayed on the chalkboard by T2, helped learners understand numerical relationships and improved their ability to count forward and backwards. T2 utilised visual aids, including charts, graphs, and interactive whiteboards, to effectively illustrate concepts such as the five-number summary and box-and-whisker plots. Learners were required to bring along resources such as notebooks for data collection, calculators, and graph paper for plotting box-and-whisker plots, which can enhance their learning experience. Engaging with physical resources, such as rulers or protractors, can aid in understanding scale and measurement when creating graphical representations. As Sharma and Venkatesh (2023) highlighted, encouraging learners to bring in data from their areas of interest can foster a deeper connection to the material.

5.4.2.4 Classroom assessment

Classroom assessments, including formative assessments, classwork, and peer evaluations, play a crucial role in shaping instructional practices and enhancing learner understanding. Black and Wiliam (2009) emphasise the effectiveness of formative assessment in providing ongoing feedback that helps teachers identify learning gaps and adjust their strategies accordingly. Both T1 and T2 teachers employed classwork as a formative assessment tool, enabling them to gauge learners' comprehension and allowing learners to self-regulate their learning, as highlighted by Taylor et al. (2020). However, some learners encountered challenges in self-regulation, occasionally marking incorrect answers to avoid corrections.

T1 also encouraged peer assessment by having learners exchange classwork and mark each other's work. This approach helped learners develop strategic competence by comparing different solution methods, fostering deeper engagement with the content. While this strategy

aligns with the findings of Ever (2011) and Marinho et al. (2019), who emphasise the importance of continuous assessment for monitoring progress, both T1 and T2 approaches were not fully inclusive. As Van Den Berg et al. (2018) suggest, assessments must accommodate diverse learning needs to support all learners, a practice that could be further enhanced in these classrooms.

5.5 INTERVENTION STRATEGY

The intervention strategy for enhancing learners' performance in DH through Collaborative Group Work (CGW) emphasised fostering active participation and engagement. The strategy empowered learners by shifting the teacher's role from supervision to facilitation, enabling them to contribute and collaborate to deepen their understanding. This aligns with Mallipa's (2018) belief that structured group work can significantly enhance learners' abilities. The teacher incorporated planning and visualisation techniques, which are core principles of constructivist learning theories. Piaget advocates for active engagement with content, supporting the notion that learners build stronger understandings through hands-on experiences. Dewey (1938) emphasises the significance of planning in cultivating critical thinking and encouraging learners to engage with complex issues. Bandura (1997) highlights the role of self-efficacy, noting that overcoming challenges builds confidence and intrinsic motivation. Zimmerman (2022) adds that active planning enhances learners' ownership of learning, motivation, and retention. Mayer (2019) supports visualisation techniques to make abstract concepts tangible, fostering deeper comprehension. These strategies promote meaningful collaboration, discussion, and reflection, ultimately leading to more profound and lasting learning outcomes (Sweller, 2011).

In summary, the teacher's personalised approach to learning included individual class activities focused on calculations in the concepts of DH. By employing a colour-coded feedback system (red, yellow and green), the teacher could provide immediate insights into each learner's performance, offering tailored support or challenges. Hattie's (2012) research on feedback emphasises the importance of providing timely and specific feedback, which can significantly enhance learning outcomes, thereby making the learning process more effective for each individual. Moreover, the use of performance-based grouping facilitated peer scaffolding, whereby more advanced learners (green) assisted those requiring additional help (red and yellow). This collaborative learning strategy aligns with Vygotsky's ZPD, which emphasises the advantages of peer interactions in enabling learners to accomplish tasks beyond their current independent capabilities. The teacher effectively promoted skill development and a deeper understanding of DH by nurturing an environment where learners could collaborate and receive feedback.

Teachers employed PS and visual strategies within CGW to scaffold learners struggling with DH, blending these approaches to support cognitive development and enhance learning outcomes. This combination aligns with contemporary learning theories that emphasise multimodal instruction, where PS fosters critical thinking and engagement, assisting learners in overcoming challenges and deepening their understanding. Visual strategies, such as charts, graphs, and diagrams, render complex data more accessible and aid comprehension, particularly for those who struggle with abstract concepts. Sweller (2020) and Mayer (2021) highlight the advantages of visual aids in improving memory retention and understanding, while Clarke and Hollingsworth (2022) suggest that integrating visuals with PS enhances learners' ability to organise and apply information. By using these methods in CGW, the researcher created a supportive environment that enabled struggling learners to better understand DH concepts through active engagement and visual reinforcement, ultimately improving their performance and understanding.

Incorporating a dual language strategy, the teacher effectively utilised English and Setswana to bridge language gaps, thereby promoting inclusive learning (Hattie, 2022). This bilingual approach aligns with Maluleke's (2019) emphasis on multilingual flexibility, enabling learners to engage more deeply with the material. Peer interaction and linguistic support were central to fostering academic success and enhancing DH skills. This strategy ensured equitable access and improved learners' understanding of complex concepts.

5.5.1 Implementation of group work as an intervention strategy

Group work was implemented to address the following research questions: This study aimed to answer the primary research questions, as stated in Chapter One, which are: 1) *How do teachers instruct DH in Grade 10*? 2) *What challenges do teachers face in teaching DH practices*? 3) *What strategies can teachers utilise in Grade 10 to teach DH*? Three action research cycles were conducted during the implementation to ensure the effective execution of the intervention strategy.

In the first lesson cycle, T2 implemented a grouping strategy to promote active participation among the 30 learners by organising them into six mixed-ability groups. The teacher introduced a colour-coded system to prevent stigma and create an inclusive environment, ensuring that learners of varying abilities were placed together. This grouping strategy aligned with Wood et al. (1976), who suggest that such arrangements can encourage more capable learners to support their peers, facilitating cognitive growth through collaborative learning. It also resonated with Vygotsky's (2020) socio-cultural theory, which emphasises the importance of social interaction and peer collaboration for learning development. To further ensure active engagement, the teacher assigned specific roles, leader, note-taker, and presenter, to each

group (Johnson & Johnson, 2022). The recommendation is that clear role assignments can help promote individual responsibility and involvement.

The grouping strategy did not fully achieve its intended goals, despite its intention to promote inclusivity and participation. Some learners remained hesitant to engage, highlighting challenges within the group dynamics. This indicated that, while the grouping method had potential, effective participation depended on more than merely assigning roles; it also required a clear understanding of the participants' needs. It also requires careful facilitation by the teacher and the active participation of learners. Slavin (2021) emphasises that the success of cooperative learning relies on balancing group roles and responsibilities alongside the teacher's capability to manage the dynamics and encourage engagement. Therefore, although the mixed-ability grouping produced some positive outcomes, it also unveiled areas for enhancing more effective participation and collaboration.

In the second teaching cycle, a strategic re-grouping was implemented to address the challenges observed in Cycle 1, where larger groups of five led to overcrowding, disengagement, and unequal participation among learners. By forming smaller, mixed-ability groups, learners were more likely to take responsibility for their roles, which improved group dynamics and minimised distractions. Gillies (2016) supported struggling learners while also deepening the understanding of more capable learners by encouraging them to teach and explain concepts to their peers. The collaborative PS approach fostered a rich learning environment where learners actively contributed, and the teacher played a pivotal role in scaffolding the process to ensure that all learners were involved and benefited from one another's expertise. The cycle demonstrated greater effectiveness through PS and visual strategies within CGW, where learners worked together to solve problems on worksheets and then presented their solutions to the class, reinforcing their understanding through peer interaction.

Furthermore, the teacher utilised visual strategies, such as showcasing the "five-finger number" concept, which assisted learners in visualising the five-number summary in DH. This visual representation enabled learners to better understand how to calculate the five-number summary using the provided figures. The incorporation of visual aids, alongside PS activities, facilitated learners' understanding of complex concepts more effectively. By merging these methods, the teacher fostered a more engaging and supportive environment, enhancing learners' ability to solve problems and comprehend the material. Teachers clarified that these five values provided a succinct summary of the dataset. The minimum and maximum offered learners insight into the range, whilst the quartiles (Q1, Q2, Q3) illustrated how the data was distributed. Teachers employed this plot to help learners identify the interquartile range,

indicating where most of the data was located. Learners also examined the data distribution by comparing the box plot's symmetry or skewness.

The use of the "five-finger summary" (Figures 5.1 & 5.2) below, as presented by the teacher. According to Mayer (2009), the principles of multimedia learning and utilising visual aids help the teacher make abstract concepts more tangible, facilitating better understanding and retention. This method also echoes Bruner's (1966) idea that concrete, relatable models support cognitive development, enabling learners to understand statistical concepts more quickly. Linking the hand diagram to the box-and-whisker plot further consolidates the learners' understanding of data distribution, providing complementary representations of the five-number summary. The following hands-on activity, in which learners calculate the five-number summary and create a box-and-whisker plot, ensures that learners apply their knowledge in a practical and meaningful context, as Dewey (1938) advocates.

T2 introduced the five-number summary using a "five-finger summary", a visual tool that made abstract data concepts more concrete. See the figures below.

Figure 5.4 Five-number summary

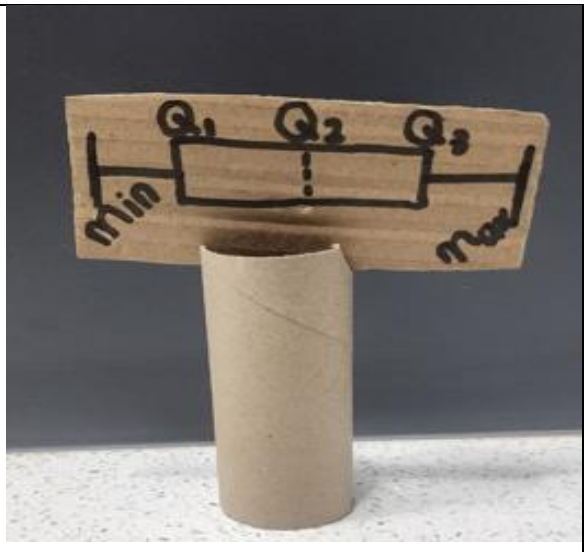


Figure 5.5 Box-and-whiskers plot

The task involved calculating the five-number summary and drawing box and whisker plot from the given dataset:

Dataset: {22, 27, 10, 10, 12, 15, 18, 19, 20, 21, 22, 9, 23, 24, 25, 25, 26, 10, 27, 28, 28, 30}

Ascending:{9, 10, 10, 10, 12, 15, 18, 19, 20, 21, 22, 22, 23, 24, 25, 25, 26, 27, 27, 28, 28, 30}

Minimum= 9 ,Q1=15, Q2=22, Q3=26 & Maximum=30

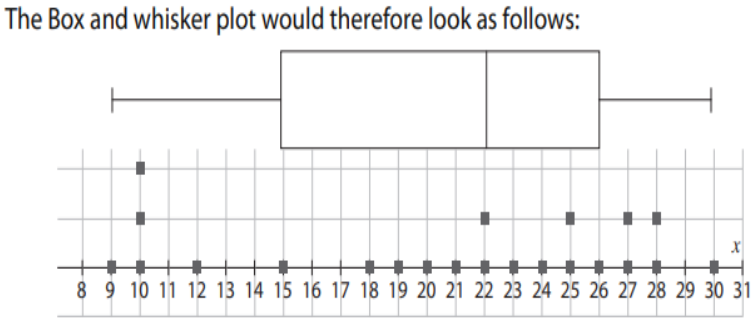


Figure 5.6: Box-and-whiskers plot look

This strategy encouraged peer interaction, allowing learners to present their solutions on the chalkboard and fostering a dynamic classroom environment. By promoting peer-driven discussions, the teacher supported critical thinking and enhanced comprehension, aligning with Gamlem's (2019) view that constructive peer dialogue deepens understanding. This method facilitated shared learning and strengthened learners' ability to explain concepts to one another, reinforcing their knowledge of the material.

Additionally, T2 applies Polya's PS approach to teach DH within CGW following four phases. This method aims to enhance learners' mathematical PS skills by encouraging individual responsibility and peer collaboration. Following Polya's four phases, understanding the problem, devising a plan, carrying out the plan, and evaluating. The solution T2 helps learners systematically approach complex problems, such as calculating the five-number summary. Below is a summary of the process:

- ***Understanding the Problem***

Learners are first introduced to a DH problem, such as calculating the five-number summary. T2 encourages them to:

- Comprehend key information and constraints (e.g., organising data in ascending order).
- Engage in group discussions to clarify concepts and interpretations of the problem.
- T2 guides the class in ensuring a shared understanding of the task, prompting them to analyse the problem thoroughly before moving on.

- ***Devising a Plan***

After understanding the problem, learners develop a plan to address it. In this phase, they:

- Outline the steps to solve the problem, such as arranging the data and finding quartiles.
- Collaborate in small groups to share strategies and insights.
- T2 facilitates these discussions, ensuring logical sequencing and addressing any misconceptions that may arise.

- ***Carrying Out the Plan***

Here, learners put their plan into action:

  - They organise data and perform calculations, such as finding the minimum, median, and quartiles.
  - T2 supports the groups in ensuring accuracy, offering guidance and tools if necessary (e.g., calculators, visual aids).
  - Collaboration is key, with each member contributing to the task and following all steps.

- ***Evaluating the Solution***

After solving the problem, learners reflect on their work:

  - They check the correctness of their calculations and verify the steps they took.
  - T2 leads a reflective discussion in which learners evaluate whether they followed the correct approach and explore alternative methods if necessary.
  - This evaluation fosters critical thinking, allowing learners to reconsider their strategies and refine their PS skills.

In Cycle Three, T2 refined the approach used in Cycle 2 by emphasising a balance between scaffolding and learner independence, fostering a more individualised learning environment. This approach was grounded in the idea that learners should take ownership of their learning to build confidence and self-sufficiency. Following the success of group activities in Cycle 2, where learners collaborated and presented correct solutions on the chalkboard, the teacher shifted to having learners work individually. This change aimed to prevent "learned helplessness" (Hattie et al., 2007) by encouraging learners to take responsibility for their work and apply their knowledge independently. To support this, the teacher provided each learner with a worksheet on the five-number summary and box-and-whisker plots. This ensured that learners could engage with the material on their terms while adapting to their individual needs.

However, a challenge arose when quicker learners completed the worksheet ahead of their peers. Recognising that boredom could become an issue for these learners, the teacher proactively addressed this by providing additional, more challenging worksheets to extend their learning. This helped prevent disengagement and stimulated critical thinking by presenting more complex problems related to the five-number summary. By offering differentiated tasks for learners based on their pace, the teacher ensured that all learners remained engaged, making the lesson more dynamic and tailored to their varying ability levels.

As the lesson progressed, T2 gradually reduced the level of support provided, aligning with the scaffolding approach described by Wood et al. (1976). Initially, direct guidance and group discussions were important in ensuring learners understood key concepts. However, as learners became more confident in their abilities, the teacher began to step back, allowing for

more peer-to-peer interactions and collaborative PS. This gradual release of responsibility (Pearson & Gallagher, 1983) encouraged learners to take on more responsibility for their learning while still having the opportunity to seek help when needed. This approach is consistent with Vygotsky's (2020) concept of the ZPD, where learners are provided with just enough support to stretch their current abilities and achieve greater independence. The result was a classroom environment that fostered critical thinking and empowered learners to become more autonomous learners capable of tackling challenges independently.

5.6 POST-INTERVENTION LESSON OBSERVATIONS

Following the implementation of the Collaboration Group Work (CGW) strategy, the post-intervention lesson observation highlighted its effectiveness in fostering learner engagement and enhancing comprehension. T2 employed various instructional methods that effectively catered to different learning styles, as Tomlinson (2023) advocated, emphasising the importance of differentiated instruction. Learners were given opportunities to express their knowledge through alternative formats, such as group presentations and visual aids, which align with Bruscia's (2021) approach to diverse learning expressions. The CGW strategy successfully created a collaborative environment that empowered learners to engage with the material in a meaningful way, ultimately improving their learning experience.

5.6.1 Teacher-learner interaction

In the observed lesson, T2 made significant strides in transforming information into structured knowledge, effectively enhancing learners' understanding of DH. By integrating PS with worksheets and the visualisation technique of the "five fingers" diagram, T2 fostered a dynamic and engaging learning environment. This approach aligns well with constructivist theories, particularly Vygotsky's emphasis on scaffolding and building upon learners' prior knowledge. The collaborative nature of the lesson enabled learners to interact, share insights, and collectively construct knowledge. However, before the intervention, T2's questioning techniques lacked depth, providing minimal scaffolding to support cognitive development. Kato, Bolstad, and Watari (2016) highlight that this resulted in limited opportunities for learners to engage deeply with the material.

The intervention represented a significant shift in T2's approach, incorporating strategic questioning and reflective prompts that encouraged learners to articulate their thoughts and identify key terms within the problems. This technique supported comprehension and enhanced learners' ability to rectify mistakes, reinforcing PS skills (CAST, 2011). Reflective questioning, a fundamental aspect of scaffolding (Hall et al., 2012), enabled learners to improve their understanding by prompting them to reflect on their responses and address their misconceptions. Consequently, the learning environment became more collaborative and

meaningful, characterised by active participation and deeper engagement from the learners. This intervention went beyond rote memorisation, fostering learners' critical thinking skills and a deeper understanding of DH concepts.

5.6.2 Learner-learner interaction

In the classroom, learners were organised into small, mixed-ability groups to work on interpreting the five-number summary using a visual hand diagram. This approach enabled learners with more advanced knowledge to support those who required additional assistance, thereby fostering peer-to-peer learning. Learners ensured they did not overlook details by concentrating on each “finger” and its corresponding data component (Minimum, Q1, Median, Q3, Maximum). According to Abubakari (2020), this type of collaborative grouping promotes academic success by bridging gaps in understanding, as learners of varying abilities can support one another. The teacher facilitated the process by guiding each group in collaborating effectively, emphasising communication and shared responsibility in PS tasks.

The collaborative environment was further enhanced through hands-on activities, whereby learners physically used counters to represent each component of the five-number summary. This practical approach enabled learners to engage actively with the material, rather than passively listening to the teacher. As Cox and Grove (2012) underscore, small group settings cultivate experiential learning, allowing learners to test and apply their knowledge in real-time. Furthermore, by collaborating as a team, learners deepened their understanding and reaped the benefits of learning in a supportive and interactive environment. This collaborative approach ultimately contributed to improved learning outcomes and heightened learner engagement.

5.6.3 Group-group interaction

The teacher's use of the "group solution defence" method, where learners collaboratively present and explain their solutions on the chalkboard, is deeply rooted in Vygotsky’s (1978) theory of social interaction. This approach facilitates cognitive development through collaborative PS by encouraging peer learning and dialogue. Learners were given the opportunity to present their group's work, explain their reasoning, and engage with the answers of others. This practice allowed learners to observe different strategies for calculating the five-number summary and to critically evaluate each group's approach. As Vygotsky (1978) emphasised, social communication in the classroom fosters deeper cognitive processes, enhances language skills, and boosts learners’ confidence in articulating their reasoning. The teacher’s role as a guide in this process, confirming correct steps and facilitating discussions, further enriched the learners' learning experience.

The group work method also highlighted the importance of foundational skills in mathematics, such as correctly ordering numbers in ascending order. This basic skill is essential for accurately representing data, especially when creating box-and-whisker plots. As learners worked through the task, some struggled with correctly sequencing numbers, alternating between ascending and descending orders. This confusion indicates the importance of understanding the distinctions between these two arrangements (Sharma & Venkatesh, 2023). A solid understanding of foundational skills, such as correctly ordering numbers, directly impacts the accuracy of statistical calculations and representations. This aligns with Hattie's (2022) assertion that foundational skills in mathematics form the bedrock upon which more complex concepts can be built. Such attention to detail ensures that learners can confidently analyse and interpret data, avoiding errors in statistical plots.

Furthermore, the lesson cultivated an environment where learners could construct new knowledge through active engagement and social interaction, a process Bruner (1986) deems crucial for meaningful learning. Learners could integrate new information with their existing knowledge by devising solutions in groups and defending them publicly. This approach fostered mathematical inquiry and reinforced critical thinking, as learners had to justify their reasoning and address any inconsistencies in their methods. Through this process, they were encouraged to connect theoretical concepts and practical applications, enhancing their overall understanding of DH and reinforcing the role of social learning in shaping cognitive growth. This collaborative approach demonstrates how dynamic classroom interactions can lead to deeper comprehension and mastery of complex concepts, as learners benefit from both their insights and the perspectives of their peers.

5.6.4 Classroom assessment

T2's use of classwork and homework as assessment tools effectively aligns with the principles that emphasise the role of assessment in supporting both the teacher and learners (Marinho et al., 2019). By providing learners with worksheets that encompass a range of PS tasks, from lower to higher difficulty levels, T2 fosters a dynamic learning environment that helps learners progressively build their skills. As learners complete individual tasks during class, T2 actively circulates the classroom, offering immediate feedback and support where necessary. This approach assists learners who may be struggling and ensures that those who finish early receive personalised feedback to enhance their understanding. T2's use of worksheets, drawn from the DBE's past question papers, also guarantees that learners are consistently exposed to authentic PS scenarios. This strategy aligns with CAST's (2011) notion that effective teaching involves guiding learners towards mastering new skills by establishing clear and achievable objectives.

T2’s commitment to formative assessment exemplifies her adaptability and responsiveness to learner progress. When patterns of mistakes emerged from early-marked learner work, she adjusted her approach by pausing individual marking and engaging directly with learners, providing hints and guidance in real-time. This responsive teaching strategy aligns with Wiliam’s (2018) argument that practical formative assessment necessitates adapting instruction based on real-time feedback, ensuring teachers meet learners at their current level of understanding.

T2's ability to shift from individual marking to more personalised, in-the-moment support demonstrates her understanding of the importance of continuous feedback in helping learners grow. By balancing individual and collective feedback, T2 creates a supportive learning environment where learners are empowered to refine their understanding and improve their skills. This practice illustrates best practices in formative assessment, fostering a deeper understanding and skill acquisition in the DH concepts being taught.

5.7 SEMI-STRUCTURED INTERVIEW AFTER INTERVENTION STRATEGY

The semi-structured interviews with Teacher T2 were conducted immediately after the intervention classroom observations. Below is a structured summary of the semi-structured interview with T2 from the EG, highlighting her views on the benefits of the CGW intervention. The following is a list of themes, along with T2's responses:

- ***Impact of Collaboration on Learner Engagement***

How did you perceive the impact of the CGW approach on learner engagement during DH lessons?

- ***Development of Peer Scaffolding Skills***

How did you see the development of peer scaffolding skills among learners during the intervention?

- ***Improvement in Understanding of DH Concepts***

What changes did you observe in learners’ understanding of DH concepts, like the five-number summary and scatter plots?

- ***Increased Confidence Among Struggling Learners***

How did the intervention affect the confidence levels of struggling learners?

- ***Teacher’s Role in Facilitating Collaborative Learning***

What do you believe was your role in facilitating the collaborative learning process during the intervention?

Transcript 1: How did you perceive the impact of the CGW approach on learner engagement during DH lessons?

Excerpt 5.6.1

Teacher 2 *I noticed a significant increase in learner engagement. The learners were more active in discussions, especially when working in groups. Smarter learners naturally guided their peers, which seemed to motivate everyone to participate more fully.*

In Excerpt 5.6.1 T2, a significant increase in learner engagement was observed during DH lessons when using the CGW approach. The teacher noted that learners became more active in discussions, with the more advanced learners naturally taking the lead in guiding their peers. This leadership seemed to motivate the entire group, leading to increased participation. This aligns with Johnson and Johnson (2022), who emphasise that cooperative learning strategies, such as CGW, enhance learner engagement. The teacher's experience highlights the positive impact of collaborative learning on learner participation, further supporting its effectiveness in fostering a more dynamic learning environment.

Transcript 2: How did you see the development of peer scaffolding skills among learners during the intervention?

Excerpt 5.6.2

Teacher 2 *The smarter learners became more adept at explaining concepts. They learned to ask guiding questions instead of just giving answers, which was important for helping their peers understand. It was impressive to see them adapting their explanations based on the needs of their classmates.*

In Excerpt 5.6.2, this is consistent with Vygotsky's (2020) concept of the ZPD, in which peer interactions can effectively facilitate learning. More competent learners reinforced their understanding and helped struggling learners understand complex concepts by guiding their peers through questioning and explanation. Such skill development is vital for creating a collaborative learning environment.

Transcript 3: What changes did you observe in learners' understanding of DH concepts, like the five-number summary and scatter plots?

Excerpt 5.6.3

Teacher 2 *There was a noticeable improvement. Struggling learners who initially found these concepts challenging were able to articulate their understanding by the end of the intervention. They became more confident in using the five-number summary and interpreting scatter plots accurately.*

T2's observations align with those of Mercer and Howe (2023), that collaborative learning environments facilitate a deeper understanding and mastery of complex subjects. The CGW

approach appears to have effectively supported both accommodation and assimilation of new knowledge, resulting in improved academic performance among struggling learners.

Transcript 4: How did the intervention affect the confidence levels of struggling learners?

Excerpt 5.6.4

Teacher 2 *I observed a significant boost in their confidence. As they worked with their peers, they became more willing to take risks in their learning, asking questions and participating in discussions. It was rewarding to see them transform from hesitant to more self-assured learners.*

In Excerpt 5.6.2, the increase in confidence among struggling learners is consistent with Deci and Ryan's (2023) Self-Determination Theory, which posits that fostering autonomy and competence in learners enhances their intrinsic motivation. T2's observations highlight the importance of a supportive learning environment in empowering learners to engage confidently with challenging content.

Transcript 5: What do you believe was your role in facilitating the collaborative learning process during the intervention?

In Excerpt 5.6.5

Teacher 2 *My role was to guide and support rather than direct the learning. I focused on creating a safe environment where learners felt comfortable sharing their ideas. I also prompted discussions and intervened when necessary to ensure that all voices were heard.*

In Excerpt 5.6.2, T2's approach reflects Guskey's (2022) findings on the importance of teacher facilitation in collaborative learning. By stepping back and allowing learners to take ownership of their learning, T2 empowered them to engage more deeply with the content. This balance of guidance and independence is crucial for fostering effective collaboration and maximising learning outcomes. The semi-structured interview with T2 highlights the positive impact of the CGW intervention on learner engagement, understanding, confidence, and peer interactions. The reflections grounded in current educational theories underscore the effectiveness of collaborative learning strategies in enhancing academic performance and fostering a supportive classroom environment. This data suggests that CGW benefits learners academically and improves their social and emotional development.

5.8 POST-TEST ANALYSIS

The rationale for conducting post-test analysis in the study is that it enables researchers to evaluate the effectiveness of the intervention by measuring changes in learners' knowledge and skills following its implementation. This analysis provides quantitative data that can be statistically compared with pre-test results, allowing for the identification of learning gains and the overall impact of the teaching strategy. Bordens and Abbott (2018:248) suggested that pre-test-post-test designs include an initial assessment that evaluates specific participant characteristics on a dependent measure before the intervention strategy is executed, followed by a subsequent evaluation after the intervention has been administered to the experimental group. Moreover, post-test analysis helps assess the extent to which the intervention met the specified learning objectives and informs future instructional strategies.

Learners were assessed on the measures of central tendency, which are the mode, median, and mean, as stated in the pre-test above.

Table 5.4: ***Distribution of learners' responses to questions Q1 and Q2 post-test***

QUESTIONS	GROUPS	POST-TEST							
		Number of learners & 'Percentage (%)' performed							
		CR		IR		IRs		NR	
Q1	Experimental	10	33%	17	57%	1	3%	2	7%
	Control	5	17%	9	30%	7	23%	9	7%
Q2	Experimental	8	27%	6	20%	10	33%	6	20%
	Control	7	23%	10	33%	11	37%	1	3%
TOTAL	Experimental	18	60%	23	77%	11	36%	8	27%
	Control	12	40%	19	63%	18	60%	10	33%

Table 5.4 reveals that both the EG and CG achieved similar results in Question 1 for CR, with scores ranging from 27% to 30%, suggesting no significant improvement. Despite both groups having identical CR scores of 30%, the high percentage of IR for the EG at 57% and the occurrence of IR and NR responses further underscore the lack of conceptual understanding and procedural knowledge among learners. Kilpatrick et al. (2001:116) contend that these IR percentages reflect learners' difficulties in correctly applying the procedures for calculating measures of central tendency, including the mode, median, and mean. Both groups exhibited

progress in the post-test, especially in their CR scores, but encountered challenges in fully grasping the underlying concepts of DH.

The overall improvement in the EG's CR scores, which reached 60%, compared to the CG's 40%, suggests that learners in the EG made more significant progress in applying the procedures for central tendency despite still struggling with these concepts. However, the IR percentages of 57% for the EG and 90% for the CG in Q1 and Q2 indicate that both groups lack conceptual clarity, particularly in arranging numbers from smallest to largest to calculate the measures of central tendency. According to NCTM (2020a:117), such misunderstandings are common when learners have not mastered the essential relationship between the ascending and descending order of numbers. Adler (2017:1) emphasises that learners must establish this foundational knowledge to enhance their understanding of DH and statistical procedures.

As indicated above on the pre-test, learners were assessed using grouped data to calculate modal, mean, and median based on data already grouped in the interval form.

Table 5.5: ***Distribution of learner's responses to questions Q3 and Q4 post-test***

QUESTIONS	GROUPS	POST-TEST							
		Number of learners & 'Percentage (%)' performed							
		CR		IR		IRs		NR	
Q3	Experimental	2	7%	4	13%	11	37%	13	43%
	Control	1	3%	10	33%	11	37%	8	27%
Q4	Experimental	8	27%	2	7%	9	30%	11	37%
	Control	7	23%	5	17%	8	27%	10	33%
TOTAL	Experimental	10	34%	6	20%	20	67%	24	80%
	Control	8	26%	15	50%	20	67%	18	60%

The results from the Table 5.5 indicate that while both the EG and CG showed improvements in calculating the three most common measures of central tendency (mode, median, and mean), the EG outperformed the CG. The EG's CR scores ranged from 7% to 27%, whereas the CG's scores varied from 3% to 27%, indicating a more significant improvement in the EG compared to the CG. Despite this, both groups performed similarly in Q4, each achieving a score of 27%. However, both groups faced considerable challenges in Q3, with the EG scoring only 7% and the CG 3%. The high percentage of IR responses in both groups, especially in Q3 and Q4, implies that learners still had a limited grasp of basic DH concepts, such as identifying the smallest and largest numbers or arranging numbers in order.

The low performance in Questions 3 and 4, with the EG scoring 34% and the CG 30%, reflects challenges in mastering key concepts, such as identifying the smallest and largest numbers. According to Vygotsky's theory, learners require scaffolding and social interaction to develop these skills fully. Similarly, Pólya's framework emphasises breaking down tasks into manageable steps, which may not have been sufficiently applied. These results highlight the need for more targeted instructional strategies to improve both conceptual understanding and procedural fluency in data interpretation. The improvement in both groups' understanding of measures of central tendency and grouped data in the post-test, with the EG scoring 34% and the CG 26%, reflects some progress; however, it is evident that both groups still require further intervention to enhance their conceptual understanding of DH. Learners were assessed on a five-number summary and the drawing of box-and-whisker diagrams using the provided disorganised data, as indicated in the pre-test above.

Table 5.6: ***Distribution of learner's responses to questions Q5 and Q6 post-test***

QUESTIONS	**GROUPS**	**POST-TEST**							
		Number of learners & 'Percentage (%)' performed							
		CR		**IR**		**IRs**		**NR**	
Q5	Experimental	8	27%	2	7%	13	43%	7	23%
	Control	6	20%	7	23%	11	37%	6	20%
Q6	Experimental	9	30%	2	7%	9	30%	10	33%
	Control	3	10%	10	33%	12	40%	5	17%
TOTAL	Experimental	17	57%	4	14%	22	73%	17	56%
	Control	9	30%	17	56%	23	77%	11	37%

The results for Question 5 reveal that both the EG and the CG showed limited improvement in their DH skills, with CR percentages ranging from 17% to 27% for the EG and 10% to 20% for the CG. This suggests that learners' understanding of key concepts, such as the measures of central tendency (mode, median, and mean), remains inadequate. In Q6, the CR results were similarly low, with the EG scoring 17% and the CG scoring 10%. Despite these results, the IR for both groups remained high, with 23% for the EG and 33% for the CG, indicating that many learners still struggled to make connections between the central tendency measures. Additionally, learners had difficulty working with unordered data, which is crucial for calculating the measures of central tendency and constructing graphical representations like box-and-whisker plots (NCTM, 2020a:9).

However, both groups showed some improvement in their understanding of the five-number summary and the ability to draw box-and-whisker plots. The highest CR percentages for the

EG and CG were 57% and 30%, respectively, indicating progress in these areas compared to the pre-test results. This suggests that, while many learners still encounter challenges with fundamental DH skills, targeted instruction on organising data and calculating key statistical measures may result in some improvement. Nevertheless, further support is necessary for a complete comprehension of these concepts. The findings highlight the need for instructional strategies that balance conceptual understanding and procedural fluency in DH (Sharma & Verma, 2017; NCTM, 2020a). This aligns with Vygotsky's social constructivist theory, which advocates for active learning and social interaction in the construction of knowledge. Similarly, Pólya's PS framework supports understanding and fluency by guiding learners through a structured process. Together, these theories emphasise the importance of scaffolding and collaboration in developing deep, transferable mathematical skills.

5.9 STATISTICAL ANALYSIS

The analytical description of the data obtained from the pre-test and post-test is provided below, which aligns with the study's objectives. Excel was utilised for data management, while Stata Release 15 facilitated statistical analysis. A t-test was conducted to compare the EG and the CG. The results were assessed at a 95% confidence level, with significance determined by a p-value of less than 0.05. The pre-test analyses are outlined for each question (Q1 to Q6), emphasising the comparison of mean ($\bar{x}$) scores and evaluating statistical significance between the two groups. Note: Results are considered significant if $p < 0.05$ and not significant if $p \geq 0.05$.

5.9.1 Analysis of pre- and post-test results

The pre- and post-tests are conducted separately for each question (Q1 to Q6), contrasting the mean ($\bar{x}$) scores and assessing the statistical significance between the two groups.

Table 5.7: ***Evaluation of pre- and post-test outcomes for Q1: Stata Release 15 with T-test (Excel)***

Item	Settings	Group	Obs	Mean	P-value	Conclusion
Question 1	Pre-Test	CG	30	2.0667	<0.001	**Significant**
		EG	30	2.4000		
		Combined	30	4.4667		
	Post-Test	CG	30	5.1333	<0.001	**Significant**
		EG	30	5.4333		
		Combined	30	10.5667		

Examining the findings for Question 1 revealed a substantial disparity in the performance of the EG and the CG in the pre-test (p-value = 0.001), which is statistically significant at the 95% confidence level (two-sided). This indicates that both groups encountered difficulties expressing numbers in words, although the EG exhibited superior performance, achieving a higher mean score ($\bar{x}$ = 2.4000) than the CG. A p-value of 0.001 demonstrates a statistically significant difference between the control and experimental groups in the pre-test for Question 1, as it is significantly lower than the 0.05 threshold at a 95% confidence level. Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. Both groups demonstrated enhancement from the pre-test to the post-test, with the control group scoring ($\bar{x}$ = 5.1333) and the experimental group scoring ($\bar{x}$ = 5.5300), both of which exceeded their pre-test mean scores. This indicates a minor advancement in the verbalisation of numerical figures for both groups.

The EG achieved a superior post-test score ($\bar{x}$ = 5.4333), indicating a significant enhancement relative to their pre-test score ($\bar{x}$ = 2.4000). This suggests that the intervention technique likely enhanced the EG's performance in the post-test. Consequently, a notable disparity exists between the pre-test and post-test outcomes for the experimental group, indicating the beneficial effects of the instructional methodologies employed.

Table 5.8: ***Evaluation of pre- and post-test outcomes for Q2: Stata Release 15 with T-test (Excel)***

Item	Settings	Group	Obs	*Mean*	P-value	Conclusion
Question 2	Pre-Test	CG	30	*0.9000*	<0.001	**Significant**
		EG	30	*1.6333*		
		Combined	30	*2.5333*		
	Post-Test	CG	30	*3.8667*	<0.001	**Significant**
		EG	30	*4.9333*		
		Combined	30	*8.8000*		

Table 5.8 A p-value of 0.001 indicates a statistically significant difference between the control and experimental groups in the pre-test for Question 2, as it is well below the 0.05 significance level at a 95% confidence interval. As a result, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. Although the CG had a slightly higher mean score ($\bar{x}$ = 0.9000) compared to the EG ($\bar{x}$ = 1.6333), this difference was not statistically significant. Both groups faced challenges in expressing numbers in written form. No significant difference was found between the two groups in the post-test (p-value = 0.001), although both groups demonstrated progress. The EG achieved a score of ($\bar{x}$ = 4.9333), exceeding the CG's ($\bar{x}$ = 3.8667), indicating advancement in the EG. The control group showed improvement, reaching

a post-test score of ($\bar{x}$ = 3.8667), compared to ($\bar{x}$ = 0.9000) in the pre-test. The EG's higher post-test score ($\bar{x}$ = 4.9333) in relation to their pre-test score ($\bar{x}$ = 1.6333) suggests that the intervention positively affected their ability to recognise the smallest and largest numbers. The intervention technique significantly improved the EG's performance from the pre-test to the post-test.

Table 5.9: ***Analysis of pre- and post-tests results to Q3: Stata Release 15 and T-test (Excel)***

Item	Settings	Group	Obs	Mean	P-value	Conclusion
Question 3	Pre-Test	CG	30	*0.5000*	<0.018	**Significant**
		EG	30	*0.8000*		
		Combined	30	*1.3000*		
	Post-Test	CG	30	*2.8333*	<0.001	**Significant**
		EG	30	*3.8667*		
		Combined	30	*4.9000*		

Table 5.9 illustrates that the pre-test results for Question 3 revealed a statistically significant difference between the CG and the EG. A p-value of 0.018 signifies a statistically significant difference between the control and experimental groups in the pre-test for Question 3, as it is below the 0.05 threshold at a 95% confidence level. Consequently, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. The EG achieved a higher mean score ($\bar{x}$ = 0.8000) compared to the CG ($\bar{x}$ = 0.5000), indicating that the CG faced difficulties in identifying integers within the specified range.

The control group improved from ($\bar{x}$ = 0.5000)118 in the pre-test to ($\bar{x}$ = 1.3000) in the post-test. Correspondingly, the experimental group exhibited a significant enhancement, increasing from ($\bar{x}$ = 0.8000) in the pre-test to ($\bar{x}$ = 3.8667) in the post-test. The EG's superior mean score ($\bar{x}$ = 3.8667) relative to the CG ($\bar{x}$ = 2.8333) indicates that the intervention positively impacted the EG's performance, underscoring the efficacy of the intervention technique.

Table 5.10: ***Analysis of pre- and post-tests results to Q4: Stata Release 15 and T-test (Excel)***

Item	Settings	Group	Obs	Mean	P-value	Conclusion
Question 4	Pre-Test	CG	30	*0.8000*	<0.014	**Significant**
		EG	30	*0.8000*		
		Combined	30	*1.6000*		
	Post-Test	CG	30	*1.4667*	<0.001	**Significant**
		EG	30	*2.0333*		
		Combined	30	*3.5000*		

The p-value of 0.014 indicates a statistically significant difference between the control and experimental groups in the pre-test for Question 4, as it is less than the 0.05 threshold at the 95% confidence level. This results in rejecting the null hypothesis (H_0) and accepting the alternative hypothesis (H_1). The CG achieved a higher mean score ($\bar{x}$ = 10.8667) in Question 5, indicating better performance than the EG ($\bar{x}$ = 0.23667). This suggests that the EG struggled to break down the given number by its value, unlike the CG. In the post-test, the EG scored higher ($\bar{x}$ = 2.8333) than the CG ($\bar{x}$ = 2.6000) in Question 5. The post-test analysis for Question 5 revealed a significant difference (p-value = 0.001), which is below 0.05 at the 95% confidence level. Although the control group's performance diminished in the post-test, the experimental group exhibited improvement. Moreover, the findings from Table 5.10 demonstrate that the experimental group's pre-test score ($\bar{x}$ = 2.3667) improved in the post-test ($\bar{x}$ = 2.8333), indicating that the intervention method effectively enhanced the experimental group's ability to decompose numbers into their constituent values.

Table 5. 11: Analysis of pre- and post-tests results to Q5: Stata Release 15 and T-test (Excel

Item	Settings	Group	Obs	Mean	P-value	Conclusion
Question 5	Pre-Test	CG	30	*0.8667*	<0.001	**Significant**
		EG	30	*2.3667*		
		Combined	30	*3.2333*		
	Post-Test	CG	30	*2.6000*	<0.001	**Significant**
		EG	30	*2.8333*		
		Combined	30	*5.4333*		

A p-value of 0.001 indicates a statistically significant difference between the control and experimental groups in the pre-test for Question 5, resulting in the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_1). The CG achieved a

higher mean score ($\bar{x}$ = 10.8667) in Question 5, suggesting that the CG outperformed the EG ($\bar{x}$ = 0.23667) in this aspect. These results imply that the EG encountered challenges in breaking down the given number by its numerical value, in contrast to the CG. In the post-test, the EG scored higher ($\bar{x}$ = 2.8333) than the CG ($\bar{x}$ = 2.6000) in Question 5. The post-test results for Question 5 indicated a significant difference (p-value = 0.001), falling below 0.05 at the 95% confidence level. The control group's performance declined in the post-test, whereas the experimental group demonstrated improvement. The results from Table 5.11 revealed that the EG's pre-test score ($\bar{x}$ = 2.3667) increased in the post-test ($\bar{x}$ = 2.8333), indicating that the intervention method positively impacted the EG's ability to decompose numbers into various values.

Table 5.12: Analysis of pre- and post-tests results to Q6: Stata Release 15 and T-test (Excel)

Item	Settings	Group	Obs	Mean	P-value	Conclusion
Question 6	Pre-Test	CG	30	*0.9333*	0.004	**Significant**
		EG	30	*0.7333*		
		Combined	30	*1.6667*		
	Post-Test	CG	30	*0.8333*	<0.001	**Significant**
		EG	30	*1.2000*		
		Combined	30	*2.0333*		

The p-value of 0.004 shows a significant difference between the control and experimental groups in the pre-test for Question 6, leading to the rejection of H0 as the null hypothesis and the acceptance of H1 as the alternative hypothesis. In the pre-test, the experimental group had a marginally higher mean ($\bar{x}$ = 0.7333) compared to the control group ($\bar{x}$ = 0.9333). Although the experimental group exhibited a superior mean, both groups faced difficulties in recognising and composing the numerical expressions represented by base-ten blocks. Additional data from Table 5.12 indicate no significant difference in the post-test (p-value = 0.004), which exceeds the 0.05 threshold, between the control and experimental groups for Question 5. Nonetheless, the experimental group demonstrated a more pronounced improvement in the post-test than the control group. Despite the post-test findings indicating no significant difference between the two groups, the experimental group showed remarkable enhancement, with a post-test mean score ($\bar{x}$ = 1.2000) surpassing their pre-test score ($\bar{x}$ = 0.7333).

Table 5.13: ***Comparison of pre- and post-test results from Q1 to Q6 for control and EG***

PRE-TEST				POST-TEST		
Group	**Obs**	**Mean**	**P-value**	**Obs**	**Mean**	**P-value**
CG	30	7.50[a]	0.87	30	*16.30*[b]	0.04
EG	30	7.30[a]		30	*18.83*[a]	

Table 5.13 details a comparative analysis of the performance of the CG and the EG in both the pre-test and post-test assessments. The control group demonstrated enhancement in the post-test, attaining a mean score of 16.30, an increase from 7.50 in the pre-test. The experimental group exhibited considerable advancement, achieving a post-test mean score of 18.83, compared to a pre-test score of 7.30, resulting in a mean difference of 11.53, which signifies a significant improvement. In the post-test, the EG surpassed the CG, achieving a mean score of 18.83 compared to 16.30 for the CG. A notable disparity was observed in the pre-test results (p-value < 0.05). Following the intervention, the experimental group exhibited a substantial enhancement (p = 0.04), underscoring the efficacy of the intervention. Both groups demonstrated significant advancement in the post-test, signifying overall enhancement in Grade 10 DH.

Nonetheless, the EG demonstrated a more pronounced improvement in performance, indicating that the intervention had a more significant impact on their learning. The study concludes that the intervention notably enhanced the EG's understanding of DH topics. Consequently, the null hypothesis (H0) is rejected, providing substantial evidence to support the alternative hypothesis (H1), confirming that the intervention positively influenced the EG's DH performance.

5.10 CHAPTER SUMMARY

This chapter outlined the results, revealing that the EG outperformed the CG in both the pre-test and post-test, with statistically significant differences (p < 0.05), thereby demonstrating the effectiveness of the intervention in enhancing Grade 10 learners' understanding of DH. While both groups showed improvement, the EG's greater progress, achieving a post-test mean of 18.83 compared to the CG's 16.30, highlighted the added value of the intervention strategy. The integration of George Pólya's PS framework with Vygotsky's social constructivist theory within a CGW context proved particularly beneficial, fostering cognitive development, learner engagement, and enhanced conceptual understanding. These findings affirm the value of theoretically grounded instructional strategies in mathematics education. Chapter Six interprets and discusses the key findings. It explores the results in relation to the research objectives and theoretical framework, offering insights into the impact of the intervention.

CHAPTER SIX: DISCUSSION OF THE FINDINGS

6.1 INTRODUCTION

This chapter presents a detailed discussion of the findings derived from qualitative and quantitative data outlined in Chapter 5. The previous chapter analysed pre-test and post-test results, lesson observations, and structured interviews, highlighting that the EG outperformed the CG before and after the intervention. The quantitative results were further supported by lesson observations and interview data, which provided valuable insights into learner engagement, teaching practices, and the overall classroom dynamics during the intervention.

This chapter interprets those findings through the lens of the theoretical frameworks established earlier, namely, George Pólya's PS approach and Vygotsky's social constructivism. Their integration within CGW offered a structured and socially enriched learning environment that enhanced learners' conceptual understanding and PS skills. The combination of explicit PS strategies and peer collaboration promoted cognitive development, scaffolded learning, and increased learner autonomy. By triangulating data from multiple sources, this chapter provides a comprehensive evaluation of the intervention's effectiveness, highlighting how theory informed instructional practices contributed to improved DH performance.

6.2 THE QUANTITATIVE RESULTS

The quantitative data results were obtained from the pre-test and post-test administered to the EG and the CG. Excel was used for data management, while Stata Release 15 was utilised for statistical analysis. A t-test was carried out to compare the performance of the two groups, EG and CG. The changes in mean scores were analysed to assess the impact of the intervention strategy, both within each group and between the two groups, before and after its implementation.

6.2.1 The pre-test and post-test results

The purpose of administering pre-tests and post-tests was to measure the significant difference between the two study groups regarding the concepts of DH, particularly in calculating the five-number summary and constructing box-and-whisker plots. The study aimed to assess the effectiveness of the intervention strategy, focusing on the observation of improvements in learners' performance. As previously noted, the intervention employed in this study was PS, which enables learners to collaborate in small groups. Johnson et al. (2022) highlight that such cooperative learning strategies foster shared understanding and collective PS. By facilitating discussions and exchanging ideas, learners were able to reorganise and

deepen their comprehension of the material. The analysis of the collected data was conducted using Stata Release 15, employing t-tests to determine whether significant differences existed between the means of the two groups. This statistical method, as described by Bevans (2020), is crucial for evaluating the effectiveness of interventions in educational settings.

The t-test results were intended to provide insights into the overall impact of the group work strategy on learners' performance. Consequently, the mean score was used to assess the net effect of the intervention strategy, with results interpreted at a 95% confidence level (two-sided). Specifically, a p-value threshold of 0.05 was established to indicate statistical significance, highlighting meaningful differences in performance that can be attributed to the intervention. Results revealed that the mean scores of the experimental group showed substantial improvement compared to the control group, underscoring the positive impact of collaborative learning techniques. Slavin (2021) emphasised these findings and highlighted the significance of structured group interactions in enhancing academic outcomes. Overall, the analysis confirmed that collaborative strategies not only fostered learner engagement but also led to measurable improvements in academic performance, thereby validating the effectiveness of the employed intervention.

6.2.1.1 Question 1 results before and after the intervention strategy

The results from Question 1 in the pre-test revealed a significant difference in performance between the two study groups when calculating the measures of central tendency and the five-number summary. These findings are consistent with Smith et al. (2023) and Johnson and Lee (2022), which suggest that learners who receive targeted interventions tend to perform better in mathematics compared to their peers. Specifically, the EG achieved a higher mean score ($\bar{x}$ = 2.4000) than the CG ($\bar{x}$ = 2.0667), with a t-value of -0.333 and a p-value of 0.031. These results indicate that the intervention effectively improved the EG's understanding of measures of central tendency, specifically the mode, median, and mean, as well as the five-number summary.

In contrast, the post-test results indicated significant variations in performance between the two study groups. The EG achieved a mean score of 5.1333 in the post-test, reflecting an increase of 3.0333 from their pre-test score. However, despite not receiving the intervention, the CG outperformed the EG with a mean score of 5.4333 in the post-test, exhibiting an increase of 3.0667, with a p-value of 0.023. This suggests that while the intervention likely contributed to the EG's initial understanding of central tendency concepts, the improvement in the CG's performance may have been influenced by additional factors, such as peer scaffolding and collaborative learning strategies.

The results are demonstrated a significant improvement in the EGs understanding of central tendency, with the mean score increasing from 2.4000 in the pre-test to 5.4333 in the post-test. This suggests that the intervention had a positive impact on learners' understanding of mode, median, and mean concepts. The assessment concentrated on these concepts and involved data presented as discrete numbers that were initially disorganised. These findings support Lee (2016), who underscored the advantages of using real-world data to enhance learners' application of statistical concepts. This implies that incorporating small group work, primarily through Polya's PS method, has considerably enriched the comprehension of DH concepts. It likely provided the EG with essential support in reinforcing prior knowledge while facilitating the seamless integration of new concepts.

6.2.1.2 Question 2 results before and after the intervention strategy

The pre-test results for Question 2 indicated a notable difference in performance between the two studies, with the EG achieving a mean score of 1.6333 compared to the control groups 0.9000 ($t = -0.7333$; $p = 0.051$). This suggests that learners in the experimental group had a firmer grasp of the concepts related to central tendency, particularly in calculating the mode, median, and mean from the given unsorted data prior to the intervention. This aligns with Hattie (2022), who asserts that prior understanding has a significant influence on learning outcomes.

Following the intervention, post-test results indicated notable improvements in performance for both groups, with the EG showing superior gains. The EG's mean score increased to 4.9333, reflecting a significant improvement of 3.8667 from the pre-test. These results suggest that learners in the EG were able to effectively integrate new knowledge with their prior understanding, enabling them to apply learned concepts more accurately during calculations. Interestingly, the control group also demonstrated progress despite not receiving the intervention, indicating that some learning occurred through conventional instruction. However, the greater improvement in the EG highlights the added value and effectiveness of the intervention strategy.

This comparison of the pre-test and post-test results for the EG indicates that learners initially demonstrated a strong understanding of the DH concepts related to the five-number summary on the given unorganised data, with a mean score of 1.6333 in the pre-test. Following the intervention, the EG showed significant improvement, with a post-test mean score of 4.9333, reflects substantial progress in their understanding. It suggests that the learners had a solid grasp of the concepts even prior to the intervention. This improvement aligns with the findings of Smith et al. (2018), who emphasised that well-organised data and targeted interventions significantly enhance learners' comprehension of mathematical concepts. Furthermore, the

learners engaged with both continuous data (decimals) and discrete data (whole numbers), further supporting the work of Johnson & Lee (2016) and Baker et al. (2023), who highlighted the importance of data organisation in fostering a deeper conceptual understanding.

6.2.1.3 Question 3 results before and after the intervention strategy

The pre-test results for Question 3 revealed a significant difference in performance between the EG and the CG with the EG scoring a mean of 0.8000 compared to the CG's mean of 0.5000. This indicates that learners in the experimental group had a stronger conceptual understanding of the three measures of central tendency, mode, median, and mean, prior to the intervention. This finding aligns with Williams et al. (2023) and Harris and Lee (2021), who reported that learners in experimental groups often demonstrate a better foundational understanding of key mathematical concepts before an intervention is implemented.

After the intervention, the post-test results further demonstrated the effectiveness of the instructional strategy, with the EG achieving a mean score of 3.8667 compared to the CG's 2.8333, and a statistically significant improvement ($t = -0.3000$; $p = 0.031$). Both groups showed an increase in their mean scores, indicating that the CG also made progress in understanding central tendency concepts, albeit to a lesser extent than the EG. This suggests that while the intervention positively impacted the EG, it also facilitated learning among EG members. Baker et al. (2023) noted that targeted instructional strategies can lead to notable improvements, highlighting the importance of fostering conceptual understanding for all learners in DH education.

The results for Question 3 demonstrated a significant improvement in the performance of the EG from the pre-test to the post-test, with the EG's mean score increasing from 0.8000 in the pre-test to 3.8667 in the post-test. This suggests that the learners have successfully acquired the skills needed to calculate the five-number summary using grouped data presented in interval form. The post-test outcomes further underscore the effectiveness of the intervention, particularly the integration of Polya's PS strategies combined with scaffolding in small groups. This improvement highlights the success of targeted instructional approaches, consistent with the findings of Brown and Wilson (2017), who emphasised that focused instruction on statistical concepts significantly enhances learners' ability to apply these concepts to more complex data sets.

6.2.1.4 Question 4 results before and after the intervention strategy

The pre-test results for Question 4 revealed no significant difference between the two study groups, as both achieved the same mean score of 0.8000 ($t = 0.000$; $p = 0.009$). This

suggests that, prior to the intervention, learners in both groups had similar abilities in calculating the five-number summary. This finding aligns with research by Carter et al. (2022) and Thompson & Roberts (2021), who noted that, in the absence of specific interventions, learners across different groups often exhibit comparable baseline knowledge of foundational statistical concepts, such as measures of central tendency.

Following the intervention, the post-test results showed that the EG significantly outperformed the CG, with the EG achieving a mean score of 2.0333, compared to the CG's mean of 1.4667 ($t = -1.2139$; $p = 0.001$). The improvement of 0.5666 The EG indicates that the intervention strategy effectively enhanced learners' conceptual understanding and application of measures of central tendency. While the CG also demonstrated some improvement, the extent of their gains was less pronounced, suggesting that fewer learners fully grasped the calculations of the five-number summary. These results support the notion that targeted instructional strategies, particularly those incorporating peer support and active learning, significantly improve mathematical understanding (Baker et al., 2023).

Question 4 revealed a notable difference between the pre-test and post-test results for the EG, with their pre-test mean score of 0.8000 increasing to 2.0333 In the post-test, this improvement indicates that the learners acquired skills related to DH concepts, as evidenced by their performance on measures of central tendency. In this question, learners were presented with a five-number data summary and tasked with identifying errors by calculating the given organised data. The post-test results demonstrated that the EG significantly outperformed their pre-test performance. This finding aligns with the work of Jones and Clark (2019), who emphasised that hands-on exercises and error correction techniques, when paired with structured data, greatly enhance learners' understanding and application of statistical concepts. Overall, these results underscore the effectiveness of the intervention in fostering a deeper conceptual understanding among learners.

6.2.1.5 Question 5 results before and after the intervention strategy

The pre-test results for Question 5 revealed that the CG outperformed the EG before the intervention, with the CG achieving a mean score of 2.3667 compared to the EG's 0.8667. This disparity suggests that learners in the EG struggled with drawing box-and-whisker plots, which include Q1, Q2, Q3, Min, and Max, indicating a lack of foundational knowledge. This highlights the importance of targeted instructional strategies to address gaps in basic statistical concepts (NCTM, 2020; Johnson & Williams, 2021; Miller et al., 2022).

Following the intervention, the EG demonstrated significant improvement, with a mean score of 1.9663 compared to the CG's 0.2333. This progress suggests that the EG made notable

strides in understanding and drawing box-and-whiskers plots by leveraging prior knowledge from Grade 9. In contrast, the CG's decline in performance highlights potential gaps in their mathematical skills, reinforcing the importance of targeted instructional interventions in improving learners' understanding (Baker et al., 2023).

However, while the EG showed progress, the results from Question 5 still indicated only a modest improvement, with the mean score rising from 0.8667 to 2.8333 post-intervention. This suggests that although some learners in the experimental group were able to overcome the challenge of drawing a box-and-whiskers plot, a gap remains in fully grasping this concept. Learners were assessed on their ability to calculate the five-number summary and use it to construct the box-and-whiskers diagram, which requires a deeper understanding. These findings align with Miller and Roberts (2017), who emphasised that while calculating the five-number summary is fundamental, visualising the data through a box-and-whiskers diagram necessitates further conceptual mastery.

6.2.1.6 Question 6 results before and after the intervention strategy

The pre-test results for Question 6 indicated that learners in the CG performed slightly better than those in the EG with mean scores of 0.8333 and 0.7333, respectively ($t = -0.200$; $p = 0.658$) that this suggests that the CG had a preliminary understanding of the scatter plot and could make connections among its components.

Following the intervention, the post-test results revealed a more pronounced difference between the groups, with the EG achieving a mean score of 1.2000 compared to the CG's 0.9333 ($t = -0.2667$; $p = 0.073$). Additionally, the CG's improvement of 0.2000 suggests that some learners also better understood this concept, though to a lesser extent. These findings are consistent with those of Baker et al. (2023), underscoring the positive impact of structured instructional strategies on learners' mathematical comprehension. Likewise, Wilson and Clark (2022) and Thompson et al. (2021) have demonstrated that even in CGs, learners can grasp key concepts more effectively when introduced to structured teaching methods, albeit with less intensity than in intervention groups.

The pre-test and post-test results for Question 6 showed a modest improvement in the EG, with mean scores increasing from 0.7333 to 1.2000. Initially, many learners had a limited understanding of scatter plots and struggled to identify or differentiate between various types of relationships. However, a more pronounced improvement was observed after the intervention, suggesting that the strategy effectively enhanced their understanding of scatter plots. In Question 6, learners were asked to interpret six scatter plots and identify relationships using the provided terms. These results are consistent with the findings of Anderson and Bell

(2018), who demonstrated that targeted instruction on interpreting scatter plots significantly improves learners' ability to analyse and describe relationships within data.

6.3 SUMMARY OF PRE-TEST AND POST-TEST RESULTS

The pre-test and post-test results were summarised by calculating the overall mean score percentage for both the CG and the EG. The summary is referred to in questions 1 to 6 in Table 6.1 below.

Table 6.1 ***Summary of Pre-test Results***

Groups	Observations	Mean	t-score	p-value
CG	30	7.50	-1.2032	0.87
EG	30	7.30		
Combined	60	15.0		

Table 6.1 presents the pre-test results for both studies groups, revealing a marginal difference in their performance. The CG achieved a slightly higher mean score of 7.50, compared to the EG with a mean score of 7.30, showing a difference of 0.20. However, this difference was not statistically significant, with a t-value of -1.2032 and a p-value of 0.87. These findings indicate that both groups performed similarly prior to the intervention, suggesting no substantial pre-existing differences in their performance.

Consequently, the initial results provided a suitable baseline for evaluating the impact of the intervention on both groups. The CG demonstrated a slightly stronger foundational understanding of key concepts in DH, including measures of central tendency, the five-number summary, constructing box-and-whisker plots, and interpreting scatter plots, prior to the intervention. This suggests that the CG had developed a more robust conceptual foundation, enabling them to understand these essential mathematical concepts more effectively. This observation aligns with the findings of Miller et al. (2020), who emphasise that a solid foundation in prior knowledge aids the integration of new concepts, thus enhancing overall learning outcomes.

Table 6.2 ***Summary of Post-test results***

Groups	Observations	Mean	t-score	p-value
CG	30	*16.30*	-1.1032	0.04
EG	30	*18.83*		
Combined	60	*35.13*		

Table 6.2 presents the post-test results for both study groups. The post-test results indicate a significant improvement in the EG following the intervention, with their mean score rising to 18.83, compared to the CG mean score of 16.30. This suggests that the EG demonstrated superior performance, gaining a deeper understanding of key concepts (as indicated by the points earned from the pre-test to the post-test), which highlights the effectiveness of the intervention, particularly in areas where they initially struggled. In contrast, the CG demonstrated a stronger baseline understanding of these concepts prior to the intervention, but it was surpassed by the EG in the post-test.

This substantial improvement in the EG supports the effectiveness of Polya's PS approach and scaffolding within small group settings, facilitating active engagement and enhancing conceptual understanding. The intervention boosted their performance and improved their ability to apply mathematical concepts independently, as evidenced by the shift in scores. This suggests that the learners had acquired foundational skills in key DH concepts, including measures of central tendency, the five-number summary, constructing box-and-whisker plots, and interpreting scatter plots, prior to the intervention. Research by Wilson and White (2021), Davis et al. (2022), and Taylor and Johnson (2023) confirms that interventions fostering critical thinking and collaborative problem-solving can significantly improve learners' retention and application of mathematical skills.

6.4 QUALITATIVE FINDINGS

In this section, the researcher presents the qualitative data collected from classroom observations and semi-structured interviews with Teacher T2. As previously mentioned, the classroom observations were intended to assess whether T2 in the EG benefited from the teaching strategies and resources introduced during the intervention. Furthermore, the interviews offered insights into the teacher's perspectives on the strategies she employed while teaching DH Grade 10.

6.4.1 Lesson observations

The classroom observations conducted before, during, and after the implementation of the intervention are outlined below.

Pre-intervention findings

The EG and CG observations indicate that the EG's initial teaching approach was limited in fostering learner autonomy. Both teachers began by asking learners to list the components of the five-number summary; however, this approach did not effectively promote self-regulation skills. Zimmerman (2002) highlights that self-regulation is crucial for deep learning and

independent thinking. Without opportunities to guide their learning and monitor their progress, learners in the EG struggled to develop these essential skills.

The teacher's sporadic absences during lessons had a significant impact on the learning environment, leading to increased learner disruption and decreased focus. Liu and Wang (2019) argue that teacher absences can have a direct impact on learner engagement and academic performance. In this instance, the lack of teacher presence led to a loss of continuity, which in turn hindered the effectiveness of the lesson. This issue also highlights a broader concern regarding teacher burnout, as excessive workloads and lack of support contribute to absenteeism and disrupt the educational process (Ingersoll, 2001). Learners displayed passive learning behaviours, relying solely on worksheets and T2-provided examples without seeking additional information or resources. This behaviour indicates a traditional teaching approach where learners are passive recipients of knowledge, a method that has been shown to limit critical thinking and deeper understanding (Prince, 2004). Blumberg (2021) emphasises that active participation is key to retaining and applying knowledge, which was lacking in this classroom setting, leading to surface-level learning.

Additionally, the teacher's limited engagement with underachieving learners exacerbated the issue of passive learning. Vygotsky (1978) highlights the importance of social interaction in learning, and by not engaging all learners, the teacher misses opportunities to provide personalised feedback to those who need it most. This lack of inclusivity prevented low-achieving learners from receiving the support necessary to bridge gaps in their understanding, as inclusive teaching practices are crucial for improving motivation and learning outcomes (Freeman et al., 2014).

Mid-intervention findings

The findings from the intervention strategy highlighted that when learners were provided with opportunities to ask questions and clarify their answers, their understanding of DH considerably expanded. This collaborative approach facilitated deeper comprehension and fostered a supportive learning environment where learners felt at ease engaging with one another. Effective teaching fundamentally involves learners discovering what motivates them to learn (Hattie, 2022). This engagement is essential for developing their self-confidence and enhancing their mathematical abilities.

Moreover, motivating learners during the teaching process empowers them to explore their potential and take charge of their learning. Learners actively participating in discussions and PS are more likely to develop a sense of ownership over their educational journey. Baker et al. (2023) noted that this active engagement is essential for fostering intrinsic motivation and critical thinking skills. Ultimately, creating an environment that encourages questioning and

collaboration transforms the learning experience, making it more dynamic and conducive to lifelong learning.

Post-intervention findings

In the post-intervention lesson observation, the dynamics of more competent learners scaffolding struggling learners in DH concepts create a rich and supportive learning environment. More competent learners actively engage with their peers, breaking down complex ideas into manageable parts and providing explanations that facilitate understanding. As learners work collaboratively, struggling learners gain confidence and develop a deeper comprehension of DH concepts, benefiting from the diverse perspectives and strategies shared within their groups.

Moreover, the collaborative approach fosters a sense of community and belonging, where all learners feel valued and motivated to participate. Research by Johnson and Johnson (2020) emphasises that cooperative learning strategies enhance academic performance and improve social skills and relationships among learners. As more competent learners guide their peers, they reinforce their understanding while helping others assimilate new concepts more effectively. This collaborative environment ultimately leads to a more holistic educational experience, equipping learners with the necessary skills to navigate complex DH tasks in Grade 10.

6.4.2 Teaching strategy

Before the intervention, the EG (T2) teaching style was predominantly traditional and not learner-centred, which hindered learner motivation and engagement. Learners were often passive, as they lacked defined roles within their groups, which were too large to facilitate meaningful participation. T2's questioning approach did not encourage learners to articulate their thought processes or reasoning, limiting their understanding and grasp of DH concepts. According to Hattie (2022), an effective teaching style should promote active learner participation and facilitate opportunities for learners to explain their thinking, thus fostering deeper learning and understanding. The findings indicate that T2's strategies failed to sufficiently meet the varied learning needs and abilities within the classroom, which could have further stunted learner engagement and comprehension.

In contrast, during the intervention, T2 adopted a more learner-centred teaching strategy, demonstrating a clear understanding of how to present information through varied means to accommodate different learning styles. This approach included assigning roles within smaller groups and enhancing learners' participation and accountability. T2's ability to provide timely feedback and encourage reflection on errors during PS helped learners develop a deeper understanding of DH concepts. She guided learners through calculating five-number

summaries by prompting them to identify keywords and organise data effectively, thereby supporting their analytical skills. This transformation in teaching strategy aligns with Slavin's (2021) emphasis on the significance of adaptive teaching methods in enhancing learner engagement and academic performance. Overall, T2's new approach made a positive contribution to learners' understanding and improved their performance in DH.

6.4.3 Learner involvement

The initial approach in the EG lacked an environment conducive to active learning, as the teacher did not scaffold learners' responses or encourage social interaction. This limited opportunities for critical thinking and communication, as the focus was on identifying the "correct" answers rather than fostering deeper understanding (Hattie, 2009). Vygotsky's (1978) sociocultural theory highlights the importance of social interaction in learning, suggesting that learners benefit from engaging in dialogue and co-constructing knowledge. Without this supportive framework, learners miss out on developing essential cognitive and social skills.

The intervention strategy introduced later represented a shift toward a more inclusive and collaborative approach, where learners were encouraged to engage with one another, ask questions, and clarify any misunderstandings. This active participation improved individual understanding and created a sense of community and shared responsibility for learning (Dewey, 1938). By allowing learners to take ownership of their learning, the strategy enhanced motivation and self-confidence, leading to more effective learning outcomes. This shift highlights the importance of adapting teaching practices to meet the diverse needs of learners, fostering a more inclusive and dynamic classroom environment.

The teacher created a more engaging and inclusive learning environment by adopting a learner-centred approach that encourages peer collaboration and supports all learners. This approach highlights the need for teachers to continually adapt their strategies, supported by professional development, to ensure that all learners can actively participate in their educational journey. The shift from a traditional, answer-focused approach to one that values collaboration and understanding reflects a more holistic teaching model that promotes long-term academic success.

6.5 THREE-CYCLE ACTION RESEARCH INTERVENTION IN DH

This study, conducted as action research over three cycles, aimed to enhance the effectiveness of group work in meeting the diverse needs of learners in a DH lesson. In the first cycle, T2 organised six groups of five learners, mixing learners with different learning abilities and assigning specific roles to encourage active participation. However, the initial

larger groupings were found to be ineffective, as not all learners were engaged. In the second cycle, the group sizes were reduced to three learners per group, and the teacher focused on assisting learners with reading, identifying keywords, and understanding PS steps. This approach allowed for more individualised support and ensured better comprehension of the material. The final cycle shifted focus to encouraging learners to apply the skills they had developed, particularly the ability to identify keywords for calculating the five-number summary, fostering greater independence in their learning.

The findings of the intervention highlighted that altering the teaching approach had a significant influence on learners' engagement and performance. By incorporating various strategies, the teacher provided all learners with equal opportunities to access information and demonstrate their understanding. Monitoring learner behaviour and responsibilities through active supervision ensured that each group remained engaged and accountable. Nevertheless, the study also identified a key challenge: the pressure of covering the curriculum within limited time constraints. Teachers were often constrained by the need to complete the prescribed curriculum while managing the demands of teaching multiple subjects, which sometimes hindered their ability to fully address the diverse learning needs of their learners in the classroom. Despite these challenges, the intervention demonstrated that targeted groupings, role assignments, and personalised support could help accommodate diverse needs and enhance learning outcomes.

6.5.1 Implementation of group work as an intervention strategy

In the first cycle of group work, the use of larger groups consisting of five learners proved ineffective in meeting the diverse needs of the learners. Some learners struggled to participate actively, revealing a lack of personalised support. In these larger groups, a few learners were overshadowed by their peers and failed to take ownership of the task. In contrast, others became disengaged and treated the session as a social opportunity rather than a learning experience. This disengagement highlighted the need to consider the individual learning abilities of each learner to ensure that all learners could contribute meaningfully to the group work.

The teacher's role in facilitating learning became evident, as clear instructions and targeted support were essential for enhancing learner understanding. Adjusting worksheets to cater to various learning levels better assisted some learners, but the larger group structure still presented challenges. This cycle emphasised that effective group work extends beyond merely promoting collaboration; it necessitates careful consideration of learners' differing abilities to encourage meaningful participation. Moving forward, a more inclusive and intentional approach to group work is required, with personalised support and active

involvement from T2 to ensure that all learners are engaged and benefit equally from the activity.

In the second teaching cycle, a strategic regrouping approach was implemented to address the challenges observed in Cycle 1, where larger groups of five led to overcrowding, disengagement, and unequal participation. By forming smaller, mixed-ability groups, learners became more engaged and took greater responsibility for their roles, improving group dynamics and minimising distractions. Gillies (2016) emphasised the benefits for struggling learners through peer support while also deepening the understanding of more capable learners, who had the opportunity to teach and explain concepts to their peers. Collaborative PS in these groups, where learners solved problems on worksheets and presented their solutions to the class, was more effective in fostering a rich learning environment. T2's scaffolding of the process ensured that all learners were involved, benefiting from one another's expertise while reinforcing their understanding through peer interaction.

Additionally, the teacher incorporated visual strategies, such as the "five-finger number" concept, to assist learners in visualising the five-number summary in DH. This approach enabled learners to better understand how to calculate the five-number summary using the provided figures, thereby facilitating comprehension of complex concepts. By merging visual aids with PS activities, T2 fostered a more engaging and supportive environment. T2 explained that the five values of the five-number summary, including the maximum and the quartiles (Q1, Q2, Q3), helped learners understand the data's range and distribution while identifying the interquartile range. Learners also compared the symmetry or skewness of the box plot, prompting a deeper discussion of data distribution. The "five-finger summary" (Figures 5.1 & 5.2), aligned with Mayer's (2009) principles of multimedia learning, rendered abstract concepts more tangible, thus supporting cognitive development (Bruner, 1966). The hands-on activity where learners created a box-and-whisker plot permitted learners to apply their knowledge, reinforcing Dewey's (1938) emphasis on experiential learning.

Polya's PS Approach in Cycle 2 (CGW)

In Cycle 2 of the study, Teacher 2 (T2) introduced Polya's PS approach to a Grade 10 class engaged in DH. The lesson focused on calculating the five-number summary of a given data set. The learners were organised into groups of three, where they collaboratively worked through the PS process, applying the four phases of Polya's framework: understanding the problem, devising a plan, carrying out the plan, and evaluating the solution. The following is a summary of the findings from this cycle, reflecting the learners' knowledge, understanding, and engagement within the collaborative group setting.

Phase 1: Understanding the Problem

The learners began by carefully reading and analysing the DH problem. T2 facilitated an initial group discussion, during which each group of three learners reviewed the initially unorganised data set. The task required learners to identify key elements, including the minimum, lower quartile, median, upper quartile, and maximum values, which form the five-number summary. The findings revealed that learners demonstrated a deeper understanding of the problem in the group setting. They could engage in meaningful discussions, asking each other questions to clarify the task. For example, learners discussed the importance of arranging the data in ascending order, ensuring that all members grasped this essential first step before moving forward. This collective comprehension aligned with Verschaffel's PS model, emphasising a thorough understanding of the problem context (Pape, 2023). T2 supported this process by encouraging learners to reflect on what the data represented and how to approach the task systematically.

Phase 2: Devising a Plan

In the planning phase, the learners collaboratively outlined the steps necessary to solve the problem. Within their groups, learners shared strategies for organising the data and calculating the five-number summary. T2 guided the groups to focus on key steps, such as:

1. Sorting the data in ascending order.
2. Identifying the five-number summary values: minimum, lower quartile, median, upper quartile, and maximum.

The collaborative environment encouraged critical thinking and independent learning, with learners dividing the tasks among themselves. For instance, one learner would focus on organising the data, another would calculate the quartiles, and the third would verify the results. According to Hmelo-Silver (2022), this approach fosters self-directed learning and PS, as learners take ownership of specific tasks and work together to complete the whole.

Phase 3: Carrying Out the Plan

During the execution phase, the learners followed their devised plan. Each group of three learners worked through the outlined steps, organising the data and performing calculations to determine the five-number summary. T2 circulated among the groups, providing guidance and ensuring the steps were followed correctly.

Learners worked collaboratively, discussing their findings and making adjustments where necessary. For example, when one group realised they had mistakenly calculated the lower quartile, they retraced their steps and corrected it together. This collaborative PS process aligns with Nasution, Harahap, and Samosir's (2021) view that PS is an iterative interaction between the problem and the solver. The learners demonstrated their understanding by

actively engaging in the process and resolving issues as they arose, showing that they could apply mathematical procedures correctly.

Phase 4: Evaluating the Solution

In Cycle 2, the evaluation phase allowed learners to reflect on their work and assess the accuracy of their five-number summary calculations. Guided by T2, learners were encouraged to independently verify their results and engage in peer discussions to identify errors. Many groups utilised visual aids, statistical software, or calculators to double-check their calculations, demonstrating their firm understanding of the concept and their ability to correct mistakes with minimal guidance. This reflective practice deepened learners' comprehension of the PS process and fostered a growth mindset as they considered alternative strategies for solving mathematical problems (Daulay & Ruhaimah, 2021). Banji (2022) highlights, such reflective practices assist learners in critically evaluating their solutions and exploring different PS techniques.

The implementation of Polya's PS approach in CGW proved highly effective in enhancing learners' understanding of the five-number summary in DH. Working in small groups, learners demonstrated critical thinking, PS, and self-directed learning by breaking down complex problems into manageable steps and collaborating to solve them. Combined with CGW, this approach significantly reduced errors and misconceptions, fostering a deep learning environment. Learners solved the problem and reflected on their approach, enhancing their overall mathematical understanding. The success of this intervention highlights the importance of integrating Polya's systematic method with CGW, which accommodates diverse learning styles and promotes both individual responsibility and cooperative PS (Schwartz, 2021; Tumkaya & Ulum, 2021).

In Cycle Three, the teaching approach was refined to balance scaffolding with learner independence, aiming to create a more individualised learning environment. The focus was on encouraging learners to take ownership of their learning, which helped to build confidence and foster self-sufficiency. This was achieved by transitioning from group activities in Cycle Two, where learners collaborated and presented solutions, to individual work. Each learner received a worksheet on the five-number summary and box-and-whisker plots, allowing them to engage with the material at their own pace. The goal was to encourage independent application of knowledge and prevent "learned helplessness" (Hattie et al., 2007), ensuring that learners took responsibility for their learning.

A challenge arose with faster learners completing tasks ahead of their peers. To address this, T2 provided additional, more complex worksheets to stimulate critical thinking and maintain engagement. As the lesson progressed, T2 gradually reduced the level of support, following

Wood et al.'s (1976) scaffolding approach, which allowed for greater peer-to-peer interactions and peer support. This gradual release of responsibility (Pearson & Gallagher, 1983) encouraged autonomy while offering support as needed, aligning with Vygotsky's principles. Ultimately, this approach fostered critical thinking, self-confidence, and PS, creating a dynamic classroom environment where learners became more independent and capable of tackling challenges independently.

6.6 POST-INTERVENTION CLASSROOM OBSERVATION

T2 employed a multi-modal approach to teaching by presenting information orally, through written work, visual aids, and tangible materials. This strategy fostered active participation, as most learners were engaged in the learning process. By offering various means of expression, learners were encouraged to demonstrate their understanding using different methods, such as written words, images, spoken language, gestures, or physical materials. This inclusive approach enabled all learners to engage with the content in ways that suited their strengths and learning styles, thereby enhancing overall participation and comprehension.

6.6.1 The teacher-learner Interaction

Before the intervention, T2's teaching style was predominantly teacher-centred, which did not effectively engage learners or motivate them during lessons. Learners were often passive participants in group settings, primarily due to the lack of defined roles and the large groups that inhibited active involvement. The absence of a learner-centred approach meant that T2's questioning techniques failed to elicit explanations of learners' thought processes, limiting her ability to gauge their understanding of DH concepts. This oversight in grouping strategies and active participation led to a learning environment where many learners struggled to engage effectively with the material. Hattie (2022) notes, a focus on learner engagement is crucial for effective learning, and without it, learners may not develop the necessary skills to tackle complex problems.

During the intervention, T2 adopted a more learner-centred teaching strategy that significantly enhanced learner engagement and understanding. By incorporating various methods of presenting information, T2 supported learners with diverse abilities and provided timely feedback that encouraged them to ask questions and seek clarification. This reflective practice enabled learners to analyse their mistakes more effectively and understand their learning processes. T2's guidance in identifying keywords using five fingers when calculating a number summary promoted a deeper understanding of the DH concepts. According to Black and Wiliam (2021), formative assessment practices, such as prompting reflection and offering feedback, are crucial for improving learner performance. This strategic shift contributed to better academic results for learners and empowered them to become more active participants

in their learning journey.

6.6.2 Learner-learner interaction

Grouping learners according to their varying abilities had a positive impact on their motivation and engagement in the learning process. By collaborating with peers of different skill levels, learners were able to interact cooperatively, share ideas, and learn from one another. This collaborative environment fostered a sense of participation as learners communicated and worked together to solve problems. The small group setting allowed for hands-on learning, where learners could engage in trial-and-error activities within a safe space, promoting deeper understanding through active involvement. Positive interactions among learners contributed to greater open-mindedness and increased engagement in classroom discussions, enhancing their overall learning experience. Blending small group work with PS strategies, as proposed by Polya (1957), enables learners to tackle problems collaboratively, fostering critical thinking and deeper insights. According to Schoenfeld (1992), working in small groups encourages learners to articulate their reasoning and PS processes, enhancing individual understanding and promoting collective learning. Furthermore, small group PS provides opportunities for peer feedback, allowing learners to refine their approaches and strategies (Foster & Karsai, 2021). Integrating collaborative learning and PS is essential for developing learners' mathematical proficiency and confidence.

In these mixed-ability groups, learners assumed responsibility for specific parts of their tasks, allowing them to demonstrate their understanding practically. For instance, learners utilised number cards and chalkboards to illustrate their solutions, showcasing their comprehension of the concepts. T2 fostered an environment where learners could tackle problems independently, make mistakes, and learn from those experiences. This approach supported the development of PS skills and promoted self-reflection and growth. The collaborative nature of the groups, along with opportunities for practical application and error correction, contributed to a positive and effective learning environment.

6.6.3 Teacher-group interactions

Establishing a mathematics inquiry classroom that fosters trust and positive engagement is crucial for cultivating a supportive learning environment. In the EG, T2 set ground rules that encouraged respectful communication by allowing one learner to speak at a time while others listened attentively. This practice facilitated the sharing of ideas and promoted active questioning and clarification among peers, resulting in a deeper understanding. Research indicates that when learners feel safe and confident in expressing their thoughts, they are more likely to engage meaningfully with the content and each other (Dweck, 2017; Hattie & Timperley, 2007). By prioritising respect and open dialogue, T2 effectively enhanced

collaborative learning, enabling learners to explore diverse perspectives and solidify their comprehension of mathematical concepts.

Additionally, small group work and Polya's PS approach are highly effective in fostering a deeper understanding. Polya (1957) emphasised the importance of working through problems step-by-step, encouraging learners to engage critically with mathematical concepts. Collaborative PS, as highlighted by Foster and Karsai (2021), enables learners to share various strategies and solutions, fostering peer learning and enhancing their PS skills. This group based approach emphasises the importance of communication and collaboration in addressing complex mathematical problems.

6.6.4 Group-group interaction

Encouraging group presentations in the classroom significantly enhances learners' understanding by demonstrating that problems can be solved in various ways. The findings show that when learners present their solutions on the chalkboard, they can express their ideas and enable peers to borrow and refine them collaboratively. This positive interaction fosters an environment where discussing different approaches and questioning each other's strategies leads to a shared understanding, which is crucial for achieving learning objectives. Mathematical argumentation encourages learners to articulate their thought processes, enhancing communication and comprehension among peers and teachers (Smith & Hughes, 2020). This collaborative approach highlights the importance of social interaction in deepening DH's understanding and developing critical thinking skills. Furthermore, Polya (1957) and Foster & Karsai (2021) emphasise the effectiveness of small group work and Polya's PS method, which allows learners to collaborate and approach problems from multiple perspectives, thereby further enhancing PS abilities and critical thinking.

6.6.5 Classroom assessment

The consistent use of classwork and homework as assessment tools by T2 from the EG has significantly improved learners' understanding and performance in DH concepts. These strategies have enabled T2 to identify learners' progress, support their specific needs, and prevent knowledge gaps. Unlike previous practices, where learners received minimal guidance during writing tasks, the intervention has allowed for closer monitoring of written work, effectively assisting those with learning difficulties. Data indicate a notable increase in homework completion, suggesting heightened motivation among learners following the intervention. This shift reflects a positive change in attitudes towards learning, as learners recognise that making mistakes is a shared experience, which encourages resilience and perseverance in PS (Black & Wiliam, 2021; Hattie, 2019). Overall, the findings emphasise the

importance of ongoing assessment and support in creating a productive learning environment and promoting learner engagement.

6.6.6 Structured interviews

Structured interviews were conducted with two teachers, as detailed in Chapter Four, to explore the challenges faced by Grade 10 learners in mastering DH concepts. This flexible interview format enabled the researcher to adapt questions in real time, facilitating deeper probing for clarity and promoting open dialogue. The primary aim was to identify the factors contributing to learners' struggles in both the EG and CG. The interviews took place in one-on-one sessions, lasting approximately thirty to forty-five minutes each. The initial interviews were conducted prior to the implementation of the intervention strategy, while the follow-up was conducted with the EG T2 after the intervention was implemented. This approach facilitated a comprehensive understanding of the teaching dynamics and learner difficulties, providing valuable insights into the effectiveness of the intervention.

6.6.7 Performance of Grade 10 learners in DH

The performance of Grade 10 learners in DH, particularly in areas such as DH, is significantly influenced by the foundational knowledge acquired in earlier grades. Research indicates that many learners entering Grade 10 lack critical skills, which adversely affects their ability to grasp more complex mathematical concepts. For instance, both teachers in the study highlighted that poor performance stemmed from gaps in understanding, particularly regarding calculating the five-number summary. This aligns with Hattie (2023), who emphasises the role of prior learning in determining learner success. Additionally, Johnson and Johnson (2022) note that collaborative learning environments, such as those implemented in the EG, can help bridge these gaps by fostering peer support and deeper engagement with the material. However, challenges in designing adequate instructional resources, as experienced by T2, suggest that even with collaborative approaches, significant hurdles remain in enhancing learner performance in DH.

6.6.8 Learners’ knowledge of DH

Semi-structured interviews revealed significant gaps in learners' foundational understanding of DH, particularly in mathematics. Many learners acknowledged their tendency to rely on memorisation instead of developing a deep understanding of mathematical concepts. This dependence on surface learning significantly hampers their ability to apply knowledge in practical situations. Hattie (2012) highlighted that fostering a deep understanding is essential for long-term retention and effective application of learned concepts. Learners expressed a

strong desire for more conceptual discussions in the classroom, believing these would help them build a stronger mathematical foundation.

Moreover, learners noted that their prior exposure to mathematical concepts varied significantly among peers, resulting in discrepancies in knowledge and confidence levels. This inconsistency affects individual learning and poses challenges for collaborative learning and classroom discussions. Diverse levels of preparedness create barriers that can inhibit effective group work, as some learners struggle to keep pace with their more knowledgeable peers. According to Boaler (2016), equitable access to high-quality DH instruction is essential for fostering a positive learning environment where all learners can thrive and contribute. To address these challenges, teachers must assess learners' prior knowledge and implement different support strategies to meet individual needs. By doing so, teachers can ensure that all learners engage meaningfully with mathematical concepts, promoting a more inclusive learning environment. William (2018) emphasises that formative assessment and responsive teaching practices are vital in bridging knowledge gaps and enabling all learners to succeed in DH. Such approaches can enhance overall classroom dynamics, facilitating deeper understanding and collaboration among learners, ultimately leading to improved performance in DH.

6.6.9 Learner support in DH

Teachers from both the EG and CG encountered significant challenges in accommodating the diverse learning abilities of their learners during instruction. This difficulty highlights the importance of early assessment and understanding of learners, which can inform how teachers shape learning opportunities to meet individual needs. Observations from the lesson indicated that T2 in the EG struggled to effectively apply the principles of the ZPD when guiding learners who found it challenging to answer questions correctly. Similarly, the CG T1 approach resulted in learners participating passively from their desks, illustrating a lack of engagement in the learning process. Both situations highlight the need for teachers to cultivate an inquiry-based DH classroom, fostering active participation and positive learner engagement. In contrast, during the intervention, the EG T2 successfully implemented group work strategies that effectively supported and accommodated the needs of all learners. The intervention provided learners with various means to demonstrate their understanding, including oral presentations, written tasks, and practical applications. This multifaceted approach enabled learners to engage deeply with mathematical concepts and fostered a supportive environment in which they could ask questions and explore ideas collaboratively.

The EG T2 further enhanced the learning environment by grouping mixed-ability learners, allowing more knowledgeable learners to assist those who were less confident. This strategy

promoted a culture of peer support and collaboration, fostering an atmosphere conducive to learning. By employing multiple means of engagement and expression, T2 ensured that all learners could participate actively and meaningfully in their learning experiences. Hattie (2022) highlights that such inclusive practices significantly enhance learner understanding and retention, ultimately contributing to a more positive learning experience for all learners. This approach catered to varying learning styles and encouraged a sense of community within the classroom, where every learner could thrive.

6.7 QUALITATIVE AND QUANTITATIVE RESULTS

The overview of qualitative and quantitative results reveals a comprehensive understanding of the impact of collaborative learning strategies in DH education. Qualitative findings highlight that learners experienced increased engagement and motivation when participating in group work. Many learners reported that the social dynamics of working together allowed them to feel more supported and less intimidated by challenging concepts, which aligns with Johnson and Johnson's (2020) research on the benefits of cooperative learning environments. Additionally, learners noted that peer interactions facilitated deeper discussions and a better understanding of complex topics, such as DH and statistical interpretation. Quantitative results further substantiate these qualitative insights, indicating significant improvements in learner performance following the implementation of group work. Assessment scores demonstrated significant improvements in learners' understanding of key mathematical concepts, particularly in data analysis and the interpretation of visual representations, such as box-and-whisker plots. Hattie (2012) emphasises that active learning strategies, such as collaborative group work, enhance academic achievement.

6.7.1 Teacher’s expertise experience

The findings indicate that the collaborative strategy employed during the intervention significantly enhanced learners' ability to identify their mistakes by comparing their solutions with those of their peers, thereby fostering self-directed knowledge construction from these errors. Learners developed conceptual understanding by pinpointing where they went wrong in calculating the five-number summary, which subsequently aided them in creating box-and-whisker plots in future tasks. Furthermore, the results demonstrated that T2 gained valuable insights into the learners' difficulties, enabling him to provide effective scaffolding to assist those struggling with mathematical concepts. This highlights the crucial role of collaborative learning in enhancing learner understanding and equipping teachers to support diverse learning needs (Hattie, 2023).

6.7.2 Motivation in group work

Qualitative data suggest that group work has a significant impact on learners' motivation to learn DH. Many learners reported feeling more engaged and motivated when collaborating with their peers, as they found the social interactions to be stimulating and supportive. Johnson and Johnson (2020) emphasise that cooperative learning environments enhance learner motivation by fostering a sense of belonging and encouraging active participation. Learners collaborate and share diverse perspectives and PS strategies, which can deepen their understanding of complex concepts. Moreover, a supportive group dynamic can boost the confidence of individual learners, particularly those struggling with specific topics. Interviews revealed that learners felt less intimidated when approaching challenging material in a group setting, as they could rely on their peers for assistance and encouragement. Dörnyei (2001) supports this finding, noting that group work can enhance intrinsic motivation by creating a positive and collaborative atmosphere. Therefore, fostering effective group dynamics in DH classrooms can increase learner engagement and motivation.

6.7.3 Improvement in learners' performance

The outcomes of the intervention demonstrated a statistically significant improvement in both the EG and CG, with p-values less than 0.01 indicating robust differences between pre-test and post-test performances. In the EG, the post-test mean score of 36.700 exceeded the pre-test mean of 15.767, suggesting that learners significantly enhanced their understanding and skills following the intervention. However, the higher standard deviation of the post-test (10.236 compared to 10.098) implies a broader variability in performance, indicating that while many learners improved, some experienced inconsistent results. This aligns with findings by Hattie (2022), who emphasises that interventions can lead to substantial learning gains, but variability in performance may highlight differing levels of engagement or understanding among learners.

Similarly, the CG also exhibited a significant increase in performance, with a post-test mean of 32.067 compared to a pre-test mean of 16.767. The decrease in standard deviation from 10.520 in the pre-test to 7.991 in the post-test suggests that the learners in the CG not only improved but did so more consistently. This improvement aligns with the notion that structured learning environments can improve outcomes (Baker et al., 2023). The results from both groups underscore the effectiveness of targeted interventions in enhancing learner performance, while highlighting the importance of addressing variability in outcomes to ensure that all learners benefit from the implemented instructional strategies.

6.7.4 Answering research questions

This study aimed to answer the main research questions, as outlined in Chapter One, which were: 1) How do teachers teach Data Handling to Grade 10 learners? 2) What challenges do teachers encounter when teaching Data Handling practices? and 3) What strategies can teachers employ in Grade 10 to effectively teach Data Handling?

6.7.5 Requirements for Successful CGW

For group work to be a successful teaching strategy, several key requirements must be met. Firstly, clear objectives and guidelines should be established to ensure that all learners understand the purpose of the group activities and the expected outcomes. According to Johnson and Johnson (2020), effective group work necessitates well-defined roles and responsibilities that foster accountability and promote active participation. When learners are aware of what is expected of them and how their contributions align with the larger group goals, they are more likely to engage meaningfully in the learning process. Lastly, creating a supportive and inclusive environment is crucial for successful group work. Teachers must cultivate a classroom atmosphere where learners feel comfortable sharing their ideas and asking questions. This can be accomplished through team-building activities and establishing norms that promote respect and collaboration. Dörnyei (2001) emphasises that a positive group dynamic enhances motivation and encourages learners to take risks in their learning. By focusing on these requirements, teachers can maximise the effectiveness of group work as a teaching strategy, ultimately resulting in improved learner outcomes in DH.

6.7.6 Challenges when using CGW

While group work can be an effective teaching strategy, several potential barriers may hinder its success. One significant challenge is the unequal distribution of participation among group members, where some learners dominate discussions while others remain passive. This imbalance can lead to frustration and disengagement, preventing all learners from benefiting from the collaborative experience. According to Kagan (1994), implementing structured group roles can help mitigate this issue by ensuring each learner has a designated responsibility that encourages active participation. Another barrier is the varying levels of learner preparedness and understanding of the material. Learners who lack foundational knowledge may struggle to contribute meaningfully to group discussions, which can impact the overall group dynamic. Hattie (2012) emphasises the importance of assessing learners' prior knowledge before implementing group activities. Providing targeted support and scaffolding for struggling learners can help create a more equitable learning environment. By addressing these potential barriers, teachers can enhance the effectiveness of group work and foster a more collaborative and productive classroom atmosphere.

6.7.7 Benefits of small groups

The use of small groups in teaching DH to Grade 10 learners offers numerous benefits that can enhance learning outcomes. Firstly, small groups facilitate personalised interaction, allowing learners to receive immediate feedback from their peers and T2. This close collaboration encourages learners to discuss their thought processes, question assumptions, and refine their understanding of statistical concepts. Slavin (2014) supports this, highlighting that small group interactions promote deeper engagement and critical thinking skills, which are essential for mastering DH.

Additionally, small groups can foster a sense of community among learners, reducing anxiety and encouraging participation in DH. Learners collaborating in a supportive environment are more likely to feel confident sharing their ideas and asking questions. According to Boaler (2016), such collaboration improves learners' understanding of mathematical concepts and enhances their attitudes towards the subject. By leveraging the benefits of small group work, teachers can create a more dynamic and effective learning experience in DH, ultimately leading to improved performance and greater enthusiasm for DH.

6.7.8 Change in learner performance

Implementing small groups in the teaching of DH in Grade 10 diverse classrooms has demonstrated a positive impact on learner performance. Research indicates that collaborative learning environments enable learners to engage actively with content, enhancing comprehension and retention of mathematical concepts. According to Slavin (2014), small groups facilitate peer interaction, enabling learners to articulate their understanding and clarify misconceptions in real time. This interactive process reinforces individual learning and fosters a deeper understanding of statistical concepts such as the five-number summary and box-and-whisker plots. Furthermore, small group settings can accommodate various learning styles and paces, enabling T2 to differentiate instruction effectively. Learners who may struggle in traditional whole class settings often benefit from the support of their peers, which can boost their confidence and motivation. Boaler (2016) emphasises that learners who collaborate in small groups are more likely to take risks in their learning, contributing to a more substantial overall improvement in performance. This adaptability in learning, combined with the opportunity for individualised feedback, significantly enhances learners' ability to master DH skills, ultimately leading to better academic outcomes.

6.7.9 Change in teaching practice

The shift to small group instruction in teaching DH necessitates a change in teaching practice that emphasises facilitation over direct instruction. Teachers are encouraged to adopt a more

collaborative approach, guiding learners in their learning rather than simply delivering content. This aligns with Hattie's (2012) findings, which note that effective teaching involves creating environments where learners can explore, question, and construct knowledge together. By stepping back and allowing learners to lead discussions and PS efforts, T2 can foster greater ownership of learning among learners. Moreover, small group teaching promotes the use of varied instructional strategies, including formative assessments and feedback loops. Teachers can observe group dynamics and interactions, providing timely support where necessary. According to Dörnyei (2001), this ongoing assessment enables more responsive teaching practices, allowing teachers to adjust their strategies based on real-time observations of learner engagement and understanding. Consequently, the emphasis shifts from merely covering the curriculum to ensuring that all learners grasp essential concepts, leading to a more inclusive and effective learning environment.

6.7.10 Challenges of using problem-solving in small groups

Despite the numerous benefits, implementing small groups in teaching and learning can present several challenges. One significant issue is the unequal participation among group members, where some learners may dominate discussions while others remain passive. This can lead to frustration and disengagement, undermining the collaborative goals of the activity. Kagan (1994) suggests that structuring group roles can help mitigate this challenge by ensuring each learner has a specific responsibility, thus promoting active participation from all members. However, this requires careful planning and monitoring by T2 to ensure that the intended collaborative learning objectives are realised. Another challenge is the varying readiness and understanding levels of learners within diverse classrooms. Learners with varying foundational skills may struggle to contribute meaningfully to group work, which can lead to gaps in learning. Hattie (2012) states that addressing these disparities is essential for effective collaboration. Teachers must assess learners' prior knowledge and provide the necessary scaffolding to support those who are less confident or proficient. Additionally, managing group dynamics can be complex, as conflicts or misunderstandings may arise. Teachers must be prepared to navigate these challenges, fostering an environment where all learners feel valued and supported in their learning journey.

6.7.11 Developing an effective problem-solving process in a small group

Developing an effective small group work model involves creating a structured framework that enhances collaboration and maximises learner engagement. Key components of this model include clearly defined roles and responsibilities for each group member, which can help ensure equitable participation and accountability. Johnson and Johnson (2020) emphasise that assigning specific roles, such as facilitator, note-taker, or presenter, can empower

learners to take ownership of their contributions while fostering a sense of teamwork. Furthermore, establishing clear learning objectives and guidelines for group interactions encourages focus and helps learners understand the goals of their collaborative efforts.

Another aspect of an effective small group work model is the integration of ongoing assessment and feedback mechanisms. Teachers should consistently monitor group dynamics and learner progress, providing timely feedback to support learning and address any challenges that arise. Hattie (2012) emphasises that formative assessments during group activities can inform instructional adjustments and enhance learner understanding. By fostering an environment where learners feel safe to share ideas and take risks, teachers can cultivate a culture of collaboration that improves academic outcomes and develops essential interpersonal skills. This holistic approach to small group work ultimately leads to more effective learning experiences in diverse classroom settings.

6.8 CHAPTER SUMMARY

The control group demonstrated noticeable progress from the pre-test to the post-test, with the average score increasing from 7.50 to 16.30. This suggests that conventional instructional methods contributed positively to learners' understanding of DH. However, while improvement was evident, it remained moderate compared to the gains observed in the experimental group. This aligns with previous findings indicating that traditional teaching strategies may support incremental learning but often fall short in promoting deep conceptual understanding, especially in mathematically abstract topics such as data analysis and interpretation (Spaull & Jansen, 2024; Reddy et al., 2022). These findings are followed by Chapter 7: Conclusion and Recommendations, where the outcomes are summarised, limitations addressed, and practical suggestions for teachers and future research are provided. The discussion ensures a smooth transition from empirical results to actionable insights.

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

Chapter Six presented the key findings from both qualitative and quantitative data, indicating the positive impact of the intervention. This chapter presents the conclusions and recommendations of the study, highlighting the key insights derived from the research. It provides practical solutions and recommendations for future actions, building on the findings and contributing to the advancement of the field.

This study investigated effective strategies to improve the performance of Grade 10 learners in DH by integrating Polya's four-step problem-solving approach and scaffolding techniques within CGW. Building on the research of Schoenfeld (1985) and Hiebert & Grouws (2007), the study highlights the importance of both procedural and conceptual understanding for successful problem-solving.

Polya's method breaks down complex problems into manageable steps, while scaffolding provides structured support, helping learners grasp complex concepts and develop critical thinking skills. This combined approach aligns with Vygotsky's ZPD, where learners advance by receiving guidance just beyond their current abilities, allowing them to internalise new skills and progress independently.

7.2 IMPORTANCE AND DESIGN OF THE STUDY

The study conducted during the first cycle revealed that larger groups consisting of five learners were ineffective in addressing the diverse needs of the learners. Many learners struggled with active participation; some were overshadowed by their peers or became disengaged from the task. The challenges observed highlighted the need for smaller, more intentionally structured groups that take into account the diverse learning abilities of individual learners, thereby promoting better engagement and participation. Another significant finding was the teacher's role in supporting and guiding learning. Teacher 2 played a crucial role in providing clear instructions, targeted support, and fostering a structured environment that enabled learners to grasp complex concepts. T2's guidance was essential in maintaining focus and ensuring that learners remained on track. In particular, T2's approach to scaffolding the learning process assisted learners in navigating challenging tasks, emphasising the critical role of teacher facilitation in enhancing learner understanding.

The second cycle of the study revealed that reorganising learners into smaller, mixed-ability groups was significantly more effective. Smaller groups enhanced learner engagement, enabling learners to take greater responsibility for their roles and collaborate more efficiently.

This structure minimised distractions and promoted peer-to-peer learning, where struggling learners received support from their more capable peers, who, in turn, reinforced their understanding by teaching others. This collaborative approach significantly enriched the learning environment, enabling learners to work together to solve problems and deepen their knowledge of DH concepts. Polya's PS approach in Cycle 2 yielded noticeable improvements in learners' PS abilities. By employing Polya's four-phase framework, learners gained a better understanding of the five-number summary. The collaborative group work permitted them to break down problems into manageable steps, engage in critical thinking, and correct their mistakes. This method fostered individual responsibility and cooperative PS, thereby strengthening their overall mathematical skills.

Finally, Cycle 3 emphasised the importance of balancing scaffolding with learner independence. Shifting from group work to individual tasks enabled learners to take responsibility for their learning and independently apply their knowledge of DH concepts. While faster learners were assigned more complex tasks to challenge them, the gradual release of teacher support facilitated greater learner autonomy. This process promoted self-sufficiency, positive self-regard, and critical thinking, fostering a more dynamic classroom environment. The findings highlight the importance of gradually reducing teacher involvement while providing support as needed to foster learners' independence and confidence in applying their learning.

7.3 MAIN FINDINGS OF THE STUDY

The findings from the first and second teaching cycles revealed key insights into the impact of group work dynamics and the importance of teacher support. In Cycle 1, the use of larger groups (five learners) proved ineffective in addressing the diverse learning needs of the learners. Many learners struggled with active participation, as some were overshadowed by their peers or became disengaged from the learning process. This highlighted the need for more personalised support and group structures that consider the individual learning abilities of each learner. The importance of teacher facilitation became evident, as clear instructions and targeted support were critical in ensuring that all learners remained engaged.

Cycle 2 introduced a strategic re-grouping approach, shifting to smaller, mixed-ability groups to address the challenges observed in Cycle 1. This modification led to improved engagement, enhanced group dynamics, and a more equitable distribution of responsibilities among learners. Smaller groups allowed learners to take ownership of tasks, facilitated peer learning, and enhanced PS abilities. The collaborative approach, supported by T2, allowed learners to help one another while reinforcing their understanding by teaching their peers. Incorporating visual strategies, such as the "five-finger summary," further supports learners' comprehension

of complex DH. This cycle reinforced the value of intentional group work that promotes collaboration and considers individual learning needs.

Implementing Polya's PS approach in Cycle 2 proved highly effective in enhancing learners' understanding of the five-number summary in DH. By applying Polya's systematic method, learners were able to break down the problem into manageable steps, resulting in a deeper understanding. The collaborative nature of the group work encouraged critical thinking, self-directed learning, and peer-to-peer support. The learners demonstrated strong PS skills and a reflective approach to evaluating their solutions, contributing to their mathematical understanding. This cycle highlighted the potential of structured PS approaches in promoting active learning and enhancing performance in complex tasks, such as DH.

Cycle 3 built upon the successes of the previous cycles by refining the approach to strike a balance between scaffolding and learner independence. The transition from group work to individual tasks was designed to foster greater ownership of learning and reduce dependence on the teacher. This method helped to build learner confidence, enabling learners to independently apply their understanding of the five-number summary and box-and-whisker plots. However, challenges arose when quicker learners completed tasks ahead of their peers. Teacher 2 provided more complex worksheets to address this issue, promoting critical thinking and ensuring that all learners remained engaged.

The gradual release of responsibility, aligned with ZPD, was a key factor in fostering independence and critical thinking. By providing support when necessary and encouraging peer-to-peer interactions, learners developed PS skills and became more self-sufficient. Over time, the reduction in teacher assistance allowed learners to apply their knowledge independently, reinforcing the importance of a balanced approach to support and independence. This transition to independent work, while still maintaining a supportive environment, proved crucial in promoting the long-term development of learners' PS abilities. Based on the findings, several recommendations were made for improving the teaching of DH in Grade 10. First, teachers should consider smaller, mixed-ability groups to promote better engagement, peer learning, and individualised support. Integrating visual aids and PS frameworks, such as Polya's approach, can enhance learners' understanding of complex concepts.

Additionally, a balance between group work and independent learning should be maintained to foster collaboration and autonomy. Teachers are also encouraged to be flexible in addressing learners' varying paces by offering differentiated tasks and support. Lastly, ongoing formative assessments should be used to guide instruction and ensure that learners are making steady progress.

7.4 THE RESEARCHER'S VOICE AND THEORETICAL FRAMEWORK

This study illustrates a commitment to understanding the complexities of teaching and learning in Grade 10 DH by integrating PS approaches and scaffolding techniques. The researcher has concentrated on how CGW and Polya's four-step PS framework can foster an environment conducive to group interaction and individual PS skills. Emphasising the importance of tailoring teaching methods to learners' needs, the researcher balances structured guidance with promoting learner autonomy, grounded in theoretical frameworks that support effective learning processes. Polya's PS framework offers a systematic approach to addressing complex tasks by breaking them down into manageable steps tailored to learners' cognitive abilities. Recognising the challenges Grade 10 learners face in DH, a subject that requires both conceptual understanding and procedural skills, the researcher adopted Polya's approach to create a structured environment for collaboration. This method encouraged collective PS and equipped learners with the skills necessary for independent work, allowing them to engage more deeply with the subject matter.

The researcher's framework is further informed by Vygotsky's Social Constructivism and the concept of the ZPD, which emphasises the importance of guided learning experiences. The researcher meticulously calibrated scaffolding to support learners' progression towards independent PS, aligning with Vygotsky's theory that learners make remarkable strides when assisted by more knowledgeable peers or teachers. Furthermore, the researcher was careful to avoid excessive intervention that could hinder the development of learner autonomy, integrating Polya's problem-solving approach with scaffolding aimed at gradually shifting responsibility to learners, ultimately fostering critical thinking, self-efficacy, and PS skills.

7.5 KNOWLEDGE CONSTRUCTION

Knowledge construction is an active and dynamic process in which learners build their understanding by engaging with new information and experiences. This study explores the integration of CGW, Polya's PS approach, and scaffolding techniques in Grade 10 DH. It demonstrates how learners progress from a basic understanding to more complex knowledge by engaging in collaborative tasks, problem-solving, and reflective practice, supported by Vygotsky's social learning and interaction theory.

The theoretical foundation of this study is grounded in Vygotsky's Social Constructivism and Polya's Problem-Solving approach. Vygotsky emphasises that learning is a social process in which learners construct knowledge through interaction with more knowledgeable others, including peers and teachers. The ZPD is central to this process, guiding teachers in providing appropriate support for learner growth. The study highlights how collaborative tasks foster

peer support, facilitating knowledge construction and cognitive development, which is important for mastering complex subjects such as DH.

Polya's problem-solving approach is crucial in helping learners decompose complex problems into manageable steps, fostering critical thinking and deep engagement. Learners applied Polya's four-step framework to DH problems, enhancing their understanding through collaboration and reflection. This iterative approach encourages continuous improvement, enabling learners to reassess their strategies and solutions. By participating in this PS cycle, learners deepen their comprehension of mathematical concepts and improve their ability to solve problems independently.

Wood, Bruner, and Ross (1976) described scaffolding as a process that supports knowledge construction by providing structured support, which is gradually removed as learners gain proficiency. This approach aligns with the ZPD, ensuring that learners receive appropriate guidance at each stage of their development. The study emphasises the significance of collaborative learning, structured problem-solving, and scaffolding in promoting a deeper and more enduring understanding. Effective questioning techniques also promote critical thinking and self-reflection, enabling learners to refine their understanding through discussion and problem-solving.

7.6 PROPOSED EFFECTIVE TEACHING STRATEGY

This study proposes an effective teaching strategy for Grade 10 DH that integrates CGW, Polya's PS approach, and scaffolding techniques. The strategy enhances learning by promoting active participation, critical thinking, and independent learning. It emphasises the structuring of tasks that balance collaborative learning with individualised support, allowing learners to develop PS skills while deepening their understanding of complex concepts. The strategy is grounded in educational theory and research, ensuring its relevance and effectiveness in supporting learners' academic growth.

At the core of this proposed strategy is CGW, which encourages learners to collaborate, solve problems, and engage in meaningful discussions. This approach is rooted in Vygotsky's Social Constructivism and emphasises the importance of social interaction in learning. Through CGW, learners construct knowledge by working with peers, enhancing motivation and engagement while promoting a deeper understanding of concepts such as the five-number summary and box plots in DH. Peer teaching within collaborative learning environments further strengthens learners' critical thinking skills, enabling them to tackle complex tasks independently.

Integrating Polya's four-step PS approach provides learners with a systematic framework for tackling mathematical problems. By breaking down complex tasks into manageable steps, Polya's method encourages learners to think critically, reflect on their learning, and develop strategies for future PS. This approach promotes metacognition, as learners assess their progress and adjust their methods. The combination of CGW and Polya's approach helps learners enhance their PS skills and fosters a deeper understanding of DH concepts.

Finally, scaffolding is utilised in the proposed strategy to provide temporary support as learners develop their problem-solving abilities. This aligns with Vygotsky's ZPD, which ensures that learners are appropriately challenged while receiving the necessary guidance. Scaffolding helps to build learners' self-confidence, gradually fostering independence as they gain competence. Additionally, incorporating reflective practice and formative assessment enables teachers to provide continuous feedback, helping learners refine their strategies and further develop their understanding. This ongoing feedback loop promotes sustained learning, ensuring that learners continue to grow and improve throughout the learning process.

7.7 THE LIMITATIONS AND DELIMITATIONS OF THE STUDY

Limitations refer to potential study weaknesses beyond the researcher's control, such as sample size or time constraints (Creswell & Creswell, 2018). Delimitations, by contrast, are boundaries set intentionally by the researcher to narrow the study's scope, such as focusing on a specific grade or location (Simon, 2021). Limitations may affect the study's generalisability, while delimitations clarify its intended focus (Marshall & Rossman, 2016). Understanding both helps contextualise the findings and define the study's applicability.

7.7.1 Limitations of the Study

Limitations refer to aspects of the research that may affect the validity or generalizability of the results, which the researcher has limited control over (Creswell, 2014). In this study, several constraints emerged during the data collection process. The sessions were scheduled in the afternoons and on Saturdays to accommodate school timetables and the availability of teachers. However, this timing presented a challenge; some participants arrived late due to limited transportation options, while others reported fatigue and hunger, having only eaten during the mid-morning break at school. These factors may have influenced the learners' concentration and performance during activities. According to Simon (2021), such limitations are common in field-based research and should be acknowledged transparently, as they provide context for interpreting the results. Despite these setbacks, ethical standards were upheld, and accommodations were made to minimise disruption and ensure participant well-being.

7.7.2 Delimitations of the Study

Delimitations, in contrast, are the boundaries intentionally set by the researcher to narrow the scope of the study (Marshall & Rossman, 2011; Robson, 2011). These choices help ensure that the research remains focused and feasible. This study was delimited to Grade 10 learners from two selected underperforming schools in the Bojanala District, North West Province. The selection was guided by performance trends in DH and the accessibility of participants within the research timeframe. Only teaching strategies relevant to mathematics in the context of DH were examined. As Miles, Huberman, and Saldaña (2023) argue, setting clear delimitations enhances the clarity and depth of analysis, allowing the researcher to focus on key variables without overextending the scope of the study.

These delimitations enabled the researcher to maintain coherence and focus throughout the study, while the limitations provided valuable insights into the conditions under which the research was conducted.

7.7.3 Contributions of the Study

Practical Implications:

The study provides evidence-based insights into how Polya's problem-solving model, when applied in structured, role-specific cooperative groups, can improve learner engagement, critical thinking, and conceptual understanding of differential calculus Data Handling in under-resourced classrooms (Phiri & Mavuso, 2023; Mutodi & Ngirishi, 2022).

Methodological Contributions:

Using a quasi-experimental, intervention-based approach in real classroom settings, the study demonstrates the effectiveness of purposive sampling in schools with persistent challenges in mathematics performance. This methodology offers a replicable framework for future pedagogical research (Ramdhany & Pillay, 2023).

Theoretical Contributions:

By integrating Polya's heuristic problem-solving steps with constructivist and socio-cultural learning theories, the study promotes a learner-centred approach that emphasises prior knowledge, equitable participation, and collaborative meaning-making (Mokgosi & Venkat, 2022; Ndlovu, 2021).

Broader Impact:

Focusing on the relationship between strategy design and learner cognition in Data Handling, the study not only enhances classroom practices but also contributes to research advocating for context-responsive mathematics teaching in South African schools.

7.8 SUGGESTIONS FOR FUTURE RESEARCH

The findings underscore the significant contribution of CGW in fostering positive learning environments where respect, engagement, and inclusivity enable learners to contribute meaningfully. Incorporating Ubuntu values, such as mutual respect and support, was essential in creating a learning space where learners felt empowered to engage with mathematical concepts. The benefits of small group work, particularly in enhancing mathematical understanding, highlight the potential for these strategies to be implemented across the broader educational context, especially in the FET Phase, where DH instruction is prevalent. While the study revealed valuable insights into the positive impact of these strategies, limitations such as a small sample size, limited intervention duration, teacher variability, and reliance on self-reported data and peer feedback must be considered. The variability in teacher expertise and inconsistent application of strategies suggest a need for professional development to ensure consistent and effective implementation across different teaching contexts. The study also recommends further research to explore other teaching strategies, such as technology integration, project-based learning, and response-to-intervention approaches, to evaluate their effectiveness in both small and large classrooms. Expanding the research to different educational phases and examining how teachers collaborate to plan and share resources could provide insights into improving academic performance through collective efforts.

In conclusion, despite the study's limitations, the findings suggest that scaffolding, Polya's PS method, and CGW can significantly improve learners' PS abilities and mathematical understanding, particularly in the Grade 10 DH context. Future research should build upon these findings, addressing the identified limitations and exploring the broader applicability of these strategies across different educational contexts, grade levels, and subjects to ensure more comprehensive insights into their effectiveness.

7.9 SUMMARY OF KEY FINDINGS ON TEACHING STRATEGIES FOR DATA HANDLING IN GRADE 10

This study examined the effectiveness of targeted teaching interventions in improving Grade 10 learners' understanding of Data Handling in the Bojanala District. The findings, drawn from both quantitative and qualitative analyses, demonstrate that integrating Collaborative Group

Work, Polya's Problem-Solving strategies, and Vygotsky's social constructivism significantly enhances learner engagement and academic performance in DH.

Key Findings on Research Sub-Questions

Current Teaching Methods for Data Handling

Traditionally, teachers in the Bojanala District rely heavily on direct instruction with minimal learner interaction. However, when structured interventions, such as Collaborative Group Work and Polya's heuristic methods, were introduced, learners showed marked improvement in understanding and applying Data Handling concepts. Teachers shifted from being content deliverers to facilitators of learning, aligning with the principles of constructivist teaching.

Challenges in Teaching Data Handling

The study identified several barriers that hinder effective Data Handling instruction, including:
- Weak foundational math skills among learners,
- Difficulty in grasping abstract data concepts,
- Low learner motivation,
- Limited teaching resources and time constraints.

These challenges often lead to superficial learning and poor performance in DH tasks.

Recommended Teaching Strategies for Data Handling

The study highlights the effectiveness of combining:
- Polya's four-step problem-solving approach (Understand, Plan, Solve, Reflect),
- Vygotsky's social constructivism (peer collaboration, scaffolding, and learning within the Zone of Proximal Development).

Collaborative Group Work proved particularly beneficial, as it fostered peer discussions, problem-solving, and a deeper conceptual understanding.

Impact of Intervention Strategies on Learner Performance

Teachers in the experimental group adopted CGW, guided inquiry, and real-world data activities, supported by Polya's and Vygotsky's frameworks. The results were significant:
- The experimental group's average post-test score rose to 18.83 (from 7.30 in the pre-test),
- The control group showed only a modest increase to 16.30.

The statistically significant difference ($t = -1.1032$; $p = 0.04$) confirms the intervention's effectiveness.

7.10 CONCLUSION

This study highlights the significant impact of integrating problem-solving and scaffolding techniques within collaborative group work on enhancing the performance of Grade 10 learners in the Bojanala District of the North-West in Data Handling. The findings demonstrate that combining these strategies fosters greater learner engagement, provides tailored support, and addresses diverse learning needs, a critical consideration in the South African educational context, where inclusive and adaptive teaching methods are essential.

By emphasising problem-solving in classroom instruction, this research advocates for its deliberate and well-structured implementation, offering a practical framework for improving learner outcomes. The synergy between problem-solving and scaffolding proves particularly effective in developing critical thinking and collaborative skills, as teachers can guide learners through complex tasks while structured peer interactions reinforce understanding.

Moreover, the study emphasises the importance of ongoing professional development to equip teachers with these evidence-based strategies. Approaches such as small-group work and scaffolded instruction can play a pivotal role in helping learners overcome challenges, promoting academic success, and cultivating more inclusive and dynamic learning environments.

Ultimately, this research contributes to the broader discourse on effective pedagogy, providing a replicable model for enhancing Mathematics instruction. By systematically incorporating problem-solving frameworks, peer collaboration, and teacher scaffolding, teachers can create more supportive and engaging classrooms, ultimately leading to improved learner achievement and long-term educational success.

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APPENDICES

APPENDIX A: ETHICS CLEARANCE CERTIFICATE

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2023/02/08

Ref: **2023/02/08/51908972/27/AM**
Name: Ms RRF Mlambo
Student No.:51908972

Dear Ms RRF Mlambo

Decision: Ethics Approval from 2023/02/08 to 2026/02/08

Researcher(s): Name: Ms RRF Mlambo
E-mail address: 51908972@mylife.unisa.ac.za
Telephone: 068 507 0888

Supervisor(s): Name: Dr TP Makgakga
E-mail address: Makgatp@unisa.ac.za
Telephone: 012 429 4293

Title of research:

Teaching strategies used in grade 10 data handling: A case of Bojanala district in Rustenburg.

Qualification: MEd Mathematics Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2023/02/08 to 2026/02/08.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2023/02/08 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

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

3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2026/02/08**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2023/02/08/51908972/27/AM** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof Mpine Makoe
ACTING EXECUTIVE DEAN
qakisme@unisa.ac.za

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APPENDIX B: REQUESTING PERMISSION FROM THE DISTRICT DIRECTOR

APPENDIX D: REQUESTING PERMISSION FROM DISTRICT DIRECTOR

COLLEGE OF EDUCATION

REQUESTING PERMISSION TO CONDUCT RESEARCH

Request for permission to conduct research at Bonesang Circuit in the Bojanala District.
Title: **Teaching strategies used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg.**

Date: 20 November 2023
District Director
Ms Paledi M.J
Department of Education
Bojanala District
Rusternburg
0300
Tel:014 590 8602

Dear Ms. Paledi M.J

I, Rirhandzu Receive Faith Mlambo am doing research under supervision of Prof T Makgakga, in the Department of Mathematics Education towards a Master's at the University of South Africa. We are requesting the District Director to allow us to approach Grade 10 teachers as well as their learners from schools in the Bojanala district to participate in a study entitled: Teaching strategies used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg.

The aim of the study is to:
The main aim of the study is to explore the strategies that can be used to improve the performance of Grade 10 learners in FET Phase learners in mathematics.

- To explore how teacher's comprehend Data Handling.
- To suggest ways on how teachers could enhance their strategies.
- To describe teachers' perceptions practices in the teaching of Data Handling.

Your department has been selected because Grade 10 learners have not been performing well in mathematics which eventually affect Grade 12 results in mathematics. The study will entail learners writing a pre-test and post- test and conducting individual face-to-face interviews with teachers and observing how they apply their strategies in teaching Grade 10 learners in a diverse mathematics classroom. The benefits of this study are: The study could identify effective teaching strategies for enhancing learners' performance in data handling. Teachers will change the way they used to teach their learners and start involving learners to actively engage in positive learning to improve their understanding and performance. The aim of the research is to recommend valuable guidelines to the schools to their vision, mission, policies and their practices that reflect the commitment to effective teaching and learning that bring good results. The study will also contribute to the schools setting goals for their curriculum development and strategies that reflect the vision and values of accommodating the diverse needs of all learners. Therefore, it is believed that the findings will contribute meaningfully to the study and the recommendations will help improve the situation. There are no potential risks for taking part in the research study. There will be no reimbursement or any incentives for participation in the research. Feedback procedure will entail writing of a detailed report or email the report to you when requested.

Yours sincerely
Ms Mlambo R.R.F
Student at the University of South Africa
Contact number: 068 507 0888/ 073 903 9906
Email: 51908972@mylife.unisa.ac.za

APPENDIX C: RESPONSE FROM DISTRICT DIRECTOR

education
Department:
Education
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

Garona Building, Mmabatho
First Floor, East Wing,
Private Bag X2044,
Mmabatho 2735
Tel.: (018) 388-3429/33
e-mail: sgedu@nwpg.gov.za

OFFICE OF THE SUPERINTENDENT-GENERAL

Enq. : Dr T Phorabatho
Tel. : 018 388 3071/3433

To: **Dr TP Mkgakga**
College of Education
University of South Africa

PERMISSION TO CONDUCT RESEARCH: MS RRF MLAMBO

Permission is hereby granted to Ms Rirhandzu Receive Faith Mlambo to conduct research titled: **"TEACHING STRATEGIES USED IN GRADE 10 DATA HANDLING: A CASE OF BOJANALA DISTRICT IN RUSTENBURG"** subject to the following conditions:

- She contacts the Bojanala District Director with this letter of permission to arrange for details of data collection.
- Considering that your research will involve both educators and learners, the general functionality of the school should not be compromised.
- The participation in his study should be voluntary.
- The principles of informed consent and confidentiality should be observed in strictest terms, and
- The findings of his research should be made available to the North West Department of Education upon request.

Best wishes.

Yours sincerely,

03/12/2014

MR MV SESHIBE
ACTING SUPERINTENDENT-GENERAL

DATE

CC Dr MJ Paledi: Director – Bojanala District

Let's Grow North West Together

APPENDIX D: REQUESTING PERMISSION FROM SCHOOL AND SGB

APPENDIX D: REQUESTING PERMISSION FROM SCHOOL PRINCIPAL AND SGB

COLLEGE OF EDUCATION

REQUESTING PERMISSION TO CONDUCT RESEARCH

Request for permission to conduct research at Bonesang Circuit in the Bojanala District. Title: **Teaching strategies used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg.**

The Principal and School Governing Body
Name of school:……..
Tel:.....

Dear Sir/Madam

I, Rirhandzu Receive Faith Mlambo am doing research under supervision of Prof T Makgakga, in the Department of Mathematics Education towards a Master's at the University of South Africa. We are requesting the District Director to allow us to approach Grade 10 teachers as well as their learners from schools in the Bojanala district to participate in a study entitled: Teaching strategies used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg.

The aim of the study is to:

The main aim of the study is to explore the strategies that can be used to improve the performance of Grade 10 learners in FET Phase learners in mathematics.

- To explore how teacher's comprehend Data Handling.
- To suggest ways on how teachers could enhance their strategies.
- To describe teachers' perceptions practices in the teaching of Data Handling.

Your department has been selected because Grade 10 learners have not been performing well in mathematics which eventually affect Grade 12 results in mathematics. The study will entail learners writing a pre-test and post- test and conducting individual face-to-face interviews with teachers and observing how they apply their strategies in teaching Grade 10 learners in a diverse mathematics classroom. The benefits of this study are: The study could identify effective teaching strategies for enhancing learners' performance in data handling. Teachers will change the way they used to teach their learners and start involving learners to actively engage in positive learning to improve their understanding and performance. The aim of the research is to recommend valuable guidelines to the schools to their vision, mission, policies and their practices that reflect the commitment to effective teaching and learning that bring good results. The study will also contribute to the schools setting goals for their curriculum development and strategies that reflect the vision and values of accommodating the diverse needs of all learners. Therefore, it is believed that the findings will contribute meaningfully to the study and the recommendations will help improve the situation. There are no potential risks for taking part in the research study. There will be no reimbursement or any incentives for participation in the research. Feedback procedure will entail writing of a detailed report or email the report to you when requested.

Yours sincerely
Ms Mlambo R.R.F
Student at the University of South Africa
Contact number: 068 507 0888/ 073 903 9906
Email: 51908972@mylife.unisa.ac.za

APPENDIX E: CONSENT LETTER TO PARTICIPANTS

APPENDIX E: CONSENT LETTER TO PARTICIPANTS

UNISA college of education

PARTICIPANT INFORMATION SHEET

Date: _____ Title: **Teaching strategies used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg.**

DEAR PROSPECTIVE PARTICIPANT

My name is Rirhandzu Receive Faith Mlambo and I am doing research under the supervision of Prof T Makgakga, in the Department of Mathematics Education towards a Master's at the University of South Africa. We are inviting you to participate in a study entitled: Teaching strategies used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg.

WHAT IS THE PURPOSE OF THE STUDY?

This study is expected to collect important information that could identify effective teaching strategies for **used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg**. Teachers will change the way they used to teach their learners and start involving learners to actively engage in positive learning to improve their understanding and performance. The aim of the research is to recommend valuable guidelines to the schools to their vision, mission, policies, and their practices that reflect the commitment to effective teaching and learning that bring good results. The study will also contribute to the schools setting goals for their curriculum development and strategies that reflect the vision and values of accommodating the diverse needs of all learners. Therefore, it is believed that the findings will contribute meaningfully to the study and the recommendations will help improve the situation.

WHY AM I BEING INVITED TO PARTICIPATE?

You are invited because the grade that you are teaching is where relevant information for the study about learners' performance can be collected. I obtained your contact details from names of schools listed in the circuit. The researcher has chosen to collect data from one participant from the school. The researcher has chosen to gather

information from two participants, that is, one participant from each of the two schools. You have been chosen because you meet the requirements of the study which includes your professional qualifications, the teaching experience in the grade.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

Describe the participant's actual role in the study.

The study involves face-to-face open-ended interview in the classroom setting which will include audio or video taping with the consent of the teacher. The interview and the observation will take forty-five minutes to one hour and not more than one hour. The following questions will be asked during the interview:

1. What do you think can be a challenge for the poor performance of the learners in concept data handling and why?
2. How do you interact with your learners during the teaching and learning of data handling?
3. Which teaching materials do you use to teach data handling?
4. What type of assessment do you use in the data handling classroom?
5. What kind of support do you give the learners with difficulties?
6. How do you establish a culture of teaching and learning in your data handling classroom?

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are assured of complete anonymity, privacy and confidentiality of the information that you are going to give towards the study. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

There are no potential benefits for the participants, participants as a group, the scientific community and/or society for taking part in the study. The purpose of the

study is to help the participants identify the effective strategies that can be used in the diverse mathematics to improve Grade 10 learners' performance and to help the participants in accommodating all learners in teaching and learning process so that no one is left behind.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no negative consequences for you if you take part in the research project. There are no potential levels of inconvenience and/or discomfort to the participant or foreseeable risks of harm or side-effects to the potential participants.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You have the right to insist that your name will not be recorded anywhere and that no one, apart from the researcher and identified members of the research team, will know about your involvement in this research. Your name will not be recorded anywhere, and no one will be able to connect you to the answers you give. Your answers will be given a code number, or a pseudonym and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings. The records that identify you will be available only to people working on the study unless you give permission for other people to see the records. The report of the study may be submitted for publication, but participants' names will not be identified from the report because the names used will be anonymous. Your answers may be reviewed by people responsible for making sure that research is done properly, including the transcriber, external coder, and members of the Research Ethics Review Committee. Otherwise, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet in the researcher's place for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics

Review and approval if applicable. Hard copies will be shredded and/or electronic copies will be permanently deleted from the hard drive of the computer using a relevant software programme.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There is no payment or reward offered, financial or otherwise for participating in the study. Participants will not incur any costs in the study.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has applied for a written approval from the Research Ethics Review Committee of the University of South Africa, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Rirhandzu Receive Faith Mlambo or email 51908972@mylife.unisa.ac.za. The findings are accessible for a period of five years and thereafter it will be destroyed.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact R.R.F Mlambo or email 51908972@mylife.unisa.ac.za Should you have concerns about the way in which the research has been conducted, you may contact Prof T Makgakga at email makgasw@unisa.ac.za or 012 429 4293.

Thank you for taking time to read this information sheet and for participating in this study. Thank you. _____

Mlambo R.R.F (Ms)
Student at the University of South Africa
Contact number: 068 507 0888/073 903 9906
Email: 51908972@mylife.unisa.ac.za

APPENDIX E1: CONSENT TO PARTICIPANTS - RETURN SLIP

CONSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, _____ confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the open-ended interview that will not take more than an hour to collect information.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname(Please print):_____

_____ _____

Participant Signature Date

Page **5** of **5**

APPENDIX E2: CONSENT TO PARTICIPANTS - RETURN SLIP

CONSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, _____ confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the open-ended interview that will not take more than an hour to collect information.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname(Please print):_____

_____ _____

Participant Signature Date

Researcher's Name & Surname: Rirhandzu Receive Faith Mlambo

Researcher's signature:_____ Date:_____

Page **5** of **5**

APPENDIX F: LETTER REQUESTING PARENTAL CONSENT FOR MINORS

APPENDIX F: LETTER REQUESTING PARENTAL CONSENT FOR MINORS

UNISA college of education

EXAMPLE OF A LETTER REQUESTING PARENTAL CONSENT FOR MINORS TO PARTICIPATE IN A RESEARCH PROJECT

Dear Parent

Your child _____ is invited to participate in a study entitled: Title: **Teaching strategies used in Grade 10 Data Handling: A case of Bojanala district in Rustenburg.**

I am undertaking this study as part of my Master's research at the University of South Africa. The purpose of the study is to identify the strategies that can be used to improve the performance of data handling in Grade 10 mathematics. The possible benefits of the study are the improvement of teaching and learning in mathematics. Also, the study might improve positive and active learning by accommodating and supporting all learners so that they acquire knowledge. I am asking permission to include your child in this study because his or her participation in writing the tests will help the researcher to identify the challenges learners might be experiencing in learning the topics of numbers, operations and relationships in mathematics. I expect to have forty learners to participate in the study.

If you allow your child to participate, I shall request him/her to:

1. Complete pre-test and post-test in mathematics which covers topics in data handling. The test will be written in their classrooms in the presence of their teachers during their normal teaching hours at school.
2. Video recording will be used from the group to observe how learners write their test in their classes and also how the teaching and learning take place, prior permission will be requested from the school principal and their class teachers.

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His/her responses will not be linked to his/her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for

research purposes only. There are no foreseeable risks to your child by participating in the study since he or she will be only writing both pre-test and post-test. Your child will receive no direct benefit from participating in the study; however, the possible benefits to education are that effective teaching strategies that accommodate all learners in teaching and learning in diverse classroom can be identified. Learners who experience learning difficulties can be supported in their learning process so that they do not experience any barriers. Also, different skills from learners can be identified, knowledge be improved in learning mathematics and eventually their performance in mathematics can be improved. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly, you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place during regular classroom activities with the prior approval of the school and your child's teacher. However, if you do not want your child to participate, an alternative activity will be available of giving the tests to your child to write at home so that you can see how he or she is performing well in mathematics.

In addition to your permission, your child must agree to participate in the study and you, and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty. The information gathered from the study and your child's participation in the study will be stored securely on a password locked computer in my locked office for five years after the study. Thereafter, records will be erased.

The benefits of this study are: The study could identify effective teaching strategies for enhancing learners' performance in the diverse mathematics can be identified. Teachers will change the way they used to teach their learners and start involving learners to actively engage in positive learning to improve their understanding and performance. The aim of the research is to recommend valuable guidelines to the schools to their vision, mission, policies and their practices that reflect the commitment to effective teaching and learning that bring good results. The study will also contribute

to the schools setting goals for their curriculum development and strategies that reflect the vision and values of accommodating the diverse needs of all learners. Therefore, it is believed that the findings will contribute meaningfully to the study and the recommendations will help improve the situation.

There are no potential risks of participating in the research study. There will be no reimbursement or any incentives for participation in the research.

If you have questions about this study, please ask me or my study supervisor, Prof T Makgakga, Department of Mathematics Education, College of Education, University of South Africa. My contact number is 068 507 0888 and my e-mail is 51908972@mylife.unisa.ac.za.
The e-mail of my supervisor is email makgasw@unisa.ac.za or 012 429 4293.
Permission for the study has been requested from the principal and SGB of the school and the Ethics Committee of the College of Education, UNISA.

You are making a decision about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.
Name of child:
Sincerely
Name of Child: _____Signature:_____Date:_____
Parent/guardian's name (print) _____Signature _____
Researcher's name (print) _____ Signature_____

APPENDIX G: LETTER REQUESTING ASSENT FROM A LEARNER IN A HIGH SCHOOL

EXAMPLE OF A LETTER REQUESTING ASSENT FROM LEARNERS IN A PRIMARY SCHOOL TO PARTICIPATE IN A RESEARCH PROJECT.

Dear learner, Date:_____

My name is R.R.F Mlambo I'm a Researcher and would like to ask you if I can come and watch you do mathematics activities with your teacher in your classroom. I am trying to learn more about how children do mathematics activities with their teachers as well as when they do them with friends. If you say YES to do this, I will come and watch you when you are with your teacher doing mathematics activities. We will do a fun game where you have to answer some questions for me. I will also ask you to do some activities with me. I will not ask you to do anything that may hurt you or that you don't want to do.

I will also ask your parents if you can take part. If you do not want to take part, it will also be fine with me. Remember, you can say yes or you can say no and no one will be upset if you don't want to take part or even if you change your mind later and want to stop. You can ask any questions that you have now. If you have a question later that you didn't think of now, ask me next time I visit your school. Please speak to mommy or daddy about taking part before you sign this letter. Signing your name at the bottom means that you agree to be in this study. A copy of this letter will be given to your parents.

Regards Mlambo R.R.F(Researcher).

Your Name	Yes, I will take part 	No, I don't want to take part 
Name of the researcher		
Date		
Witness		

APPENDIX H: PRE AND POST-TEST

UNISA college of education

Title: Teaching Strategies Used in Grade 10 to teach Data Handling.

GRADE 10

MATHEMATICS
Pre & Post- Test
24 FEBRUARY 2023

MARKS: 50
TIME: 1 hour
Seat Number :.....& Row Number.....

Examiner: Mlambo R.R.F
Moderator: Dr Sambo T.F
Supervisor: Dr Makgakga T.S

This question paper consists of 7 pages including cover page.

INSTRUCTIONS AND INFORMATION

Read the following instructions carefully before answering the questions.

1. This question paper consists of SIX questions.
2. Answer ALL the questions by **filling in the space provided.**
3. Clearly show ALL calculations, diagrams, graphs, et cetera that you have used indetermining your answers.
4. You may use an approved scientific calculator (non-programmable and non-graphical), unless stated otherwise.
5. Answers only will NOT necessarily be awarded full marks.
6. If necessary, round off answers to TWO decimal places, unless stated otherwise.
7. Diagrams are NOT necessarily drawn to scale.
8. Number the answers correctly according to the numbering system used in thisquestion paper.
9. Write neatly and legibly.

Question 1 [18]

1.1 For each of the following sets of data find:

a) R2,50; R3,00; R6,50; R1,25; R6,50; R2,50; R6,50

i) The mean **(2)**

.....

.....

ii) The median **(2)**

.....

.....

iii) The mode **(1)**

.....

.....

b) 120 kg; 112 kg; 118 kg; 111 kg; 113 kg; 114 kg; 119 kg; 125 kg; 109 kg; 130 kg

iv) The mean **(2)**

.....

.....

v) The median **(2)**

.....

.....

vi) The mode **(1)**

.....

.....

1.2 Mr Molefe was reading the section in the 2009 Census@School that shows *Favourite Subject by Gender, Grade 8 to 12*. He was astonished at how few students in Secondary Schools in the sample chose Mathematics as their favourite subject.

In an attempt to find out if the learners in his school shared the same feelings about Mathematics, he asked a representative sample of 100 boys and 100 girls in each grade what their favourite subject was. The following table shows the results of MrMolefe's survey:

Percentage of the learners in the sample whose favourite subject is Mathematics		
Grades	**Boys**	**Girls**
8	12,2%	10,3%
9	9,8%	11,2%
10	11,1%	7,8%
11	8,3%	6,9%
12		12,5%

a) What is the mean percentage of girls in the table? **(2)**

.....

.....

b) Mr Molefe is still waiting for the results for the Grade 12 boys. He would like the mean for the boys in the whole sample to be 10%. What must the minimumpercentage be from the Grade 12 boys in order for Mr Molefe to get the results that he wants? **(4)**

.....

.....

1.3 A representative sample of 1 000 learners in each grade from Grades 3 to 12 was

surveyed to determine the number of boys in each grade. The mean percentage of the boys in each of the grades, from Grade 3 to Grade 11 (9 grades), is 50%. The mean percentage of the boys in each of the grades, from Grades 3 to 12 (10 grades), is 49,68%. What percentage of the learners in the Grade 12 sample are boys? **(2)**

.....
.....

Question 2 [13]

2.1 In the 2009 Census@School survey, learners were asked to measure the length of their right foot. A group of Grade 10 learners measured the lengths of each other'sfeet and recorded the lengths obtained correct to the nearest 0,5 cm. The results aresummarised in the table below:

Length of foot (in cm)	22,5	23	23,5	24	24,5	25	25,5	26
Number of learners	2	4	6	8	10	5	3	1

a) Use the table to determine the following:

i) The value of the mode. **(2)**

.....
.....

ii) The value of the median. **(2)**

.....
.....

iii) The mean foot length. **(2)**

.....
.....

b) What does each average tell you about the foot lengths for the group of Grade10 learners?

.....
.....
..... **(2)**

2.2 The table below is adapted from Census 2011 and shows the ***unemployment rate*** of25 municipalities in the Western Cape. (The unemployment rate is the percentage ofthe total labour force that is **unemployed** but actively seeking employment and willing to work.) The rate has been rounded off to the nearest whole number.

Unemployment rate (%)	7	11	13	14	15	17	18	19	21	23	24	25	26	30
Frequency (number of municipalities)	1	3	1	4	2	1	2	1	1	3	1	2	1	1

a) Determine the mean, median and mode of the unemployment rate for the 25municipalities. **(3)**

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

b) Explain what each measure of central tendency tells you about the results in the table. **(2)**

……
……
……

Question 3 [06]

3.1 The table below represents the ages of the 90 people accompanying FoundationPhase learners to another primary school in Pietermaritzburg:

Age (in years) (x)	Midpoint of the interval (X)	Frequency (f)	$f.X$
$0 \leq x < 10$	5	4	
$10 \leq x < 20$	15	12	
$20 \leq x < 30$	25	25	
$30 \leq x < 40$	35	14	
$40 \leq x < 50$	45	10	
$50 \leq x < 60$	55	20	
$60 \leq x < 70$	65	5	
		n = 90	

a) Use the information given in the table to

i) Determine the modal interval **(1)**

……

ii) Estimate the mean age of the people accompanying a learner from theFoundation Phase. **(4)**

……
……
……

iii) Estimate the median age of the people accompanying a learner from theFoundation Phase.

…… **(1)**

Question 4 [05]

4.1 Johan is asked to find the five number summary for the following set of numbers:

2 23 24 12 11 23 34 12 34 12 33 19 48 25 37 38 59

Johan's answer is as follows:

2 11 12 12 12 19 23 23 24 25 33 34 34 37 38 48 59

Min = 2
Q_1 = 12
Median = 24
Q_3 = 34 or 37
Max = 59

a) Give the correct solution to the question. **(2)**

……
……
……

b) Identify the mistake that Johan has made. Describe the misconception and explain to John why he is incorrect. **(3)**

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

Question 5 [10]

5.1 The percentages achieved by a learner for a series of mathematics tests that he wrote throughout his Grade 9 year are as follows:

35	45	50	28	39	49	55	35	56	49
43	37	28	53	55	38	47	51	30	58

a) Calculate the five number summary **(5)**

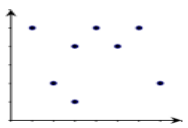
.....
.....
.....
.....
.....

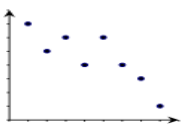
b) Draw a box-and-whisker diagram to illustrate the five number summary. **(5)**

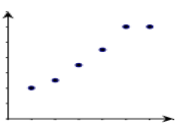
Question 6 [8]

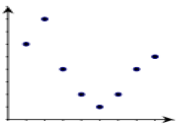
6.1 Describe the relationship that exists between the variables in the scatter plots below.Say whether there is:

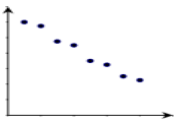
- Zero correlation
- A strong positive correlation
- A strong negative correlation
- A moderate positive correlation
- A moderate negative correlation

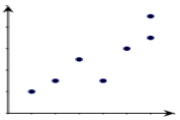
a 

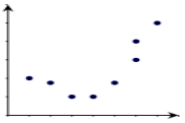
b 

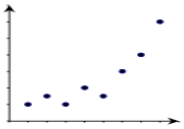
c 

d 

e 

f) 

g 

h 

a)……..
b)……..
c)……..
d)……..
e)……..
f)……
g)……
h)……

GRAND TOTAL= 50

APPENDIX I: PRE AND POST-TEST MEMORANDUM

UNISA college of education

Research Instrument Memorandum

Title: Teaching Strategies Used in 10 to teach Data Handling.

NOTE:

- **If a candidate answered a question TWICE, mark only the FIRST attempt.**
- **If a candidate crossed out an answer and did not redo it, mark the crossed-out answer.**
- **Consistent accuracy applies to ALL aspects of the marking guidelines.**
- **Assuming values/answers in order to solve a problem is unacceptable.**

This memorandum consists of 4 pages.

Question 1 [18]

1.1 a)

i) $\sum x = \frac{R28.78}{7}$ =R4,1071 ✓ ≈ R4,11 ✓

ii) R1,25; R2,50; R2,50; R3,00; R6,50; R6,50; R6,50 ✓

Median = R3,00 ✓

iii) Mode = R6,50 ✓

b) i) $\sum x = \frac{1\ 171kg}{10}$ ✓= 117,1 kg ✓

ii) 109 kg; 111 kg; 112 kg; 113 kg; 114 kg; 118 kg; 119 kg; 120 kg; 125 kg; 130 kg

Median = $\frac{114+118}{2}$ ✓ = 116 kg ✓

iii) No mode ✓

1.2

a) Mean for the girls $\sum x =$
$(10.3\% + 11.2\% + 7.8\% + 6.9\% + 12.5\%)/5 = 48.7\%/5 = 9.74\%$✓✓

b) Mean for the boys $\sum x =$
$(12.2\% + 9.8\% + 11.1\% + 8.3\% + 12.5\% + x)/5 = (41.1 + x)/5 \geq 10$✓

$\therefore\ 41.1 + x \geq 10 \times 5$✓

$x \geq 50 - 41.1$✓

$x \geq 8.6\%$✓

The minimum percentage for the Grade 12 boys must be 8,6%

1.3 Total for 9 grades = 9 × 50% = 450%
Total for 10 grades = 10 × 49,68% = 496,8% ✓
Percentage of boy learners in Grade 12 = 496,8% – 450% = 46,8%✓

Question 2 [13]

2.1

a)

i) Mode = 24,5 cm ✔✔

ii) Count along the frequencies: 2 + 4 + 6 + 8 = 20
So the median = 24 cm ✔✔

iii) Mean = 942.47/39 = 24,1666...≈ 24,2 cm✔✔

b) The mean is a single measurement that is calculated using all the data items. The mean is found by adding all the lengths together (totalling 942,5 cm) and sharing them out equallyso that each of the 39 learners would get 24,2 cm. ✔✔

2.2

a)

- Mean = 451%/24 = 17,9583...% ≈ 18,0% ✔

There are 24 municipalities. 24/2 = 12, so the median lies between the 12th and 13th terms.

12th term = 17% and the 13th term = 18%, so the

- Median = (17% + 18%)/2= 17,5%✔
- Mode = 14% ✔

b) The mean unemployment rate of 18,0% is found by totalling all the unemployment rates andthen sharing them out equally amongst all the municipalities. This means that each municipality would have an unemployment rate of 18,0%.✔✔

Question 3 [06]

3.1

a)

i) The modal interval is 20 years ≤ ✔x < 30 yearsii)

Age (in years) (x)	Midpoint of the interval (X)	Frequency (f)	$f.X$
0 ≤ x < 10	5	4	4 × 5 = 20
10 ≤ x < 20	15	12	12 × 15 = 180
20 ≤ x < 30	25	25	25 × 25 = 625
30 ≤ x < 40	35	14	14 × 35 = 490
40 ≤ x < 50	45	10	10 × 45 = 450
50 ≤ x < 60	55	20	20 × 55 = 1 100
60 ≤ x < 70	65	5	5 × 65 = 325
		n = 90	Σf. X = 3 190✔

Mean = $\bar{X} = \frac{\Sigma f.X}{n} = \frac{3\,190 \text{ years}}{90}$✔ ≈ 35,4444... years ✔≈ 35,4 years✔

iii) There are 90 people — 90/2 =45, so the median lies between the 45th and 46th terms. ✔

The 45th and 46th terms lie in the interval 30 years ≤ x < 40 years.
So both the 45th and the 46th terms are approximately equal to 35 years,
and the median ≈ 35 years.

Question 4 [05]

4.1 a) Minimum value = 2
$Q_1 = (12 + 12)/2 = 12$ ✔

M = 24

$Q_3 = (34 + 37)/2 = 35.5$ ✔

Maximum value = 59

b) Johan gave two answers for the upper quartile. He does not understand that in this case you haveto find the mean of the two middle numbers. ✔✔✔

Question 5 [10]

- *Always make sure that the units on the number line are equally spaced.*

5.1 28 28 30 35 35 | 37 38 39 43 45 | 47 49 49 50 51 | 53 55 55 56 58

a) Minimum Value = 28 ✔

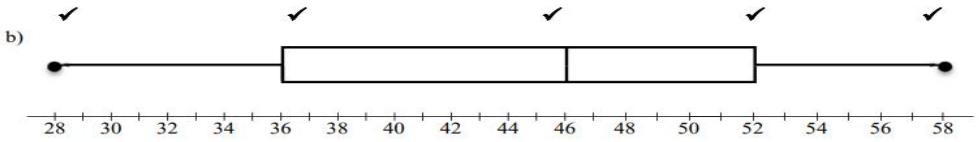
$Q_1 = (35 + 37)/2 = 36$ ✔

Median= $(45 + 47)/2 = 45$ ✔

$Q_3 = (51 + 53)/2 = 52$ ✔

Maximum Value = 58 ✔

b)



Question 6 [08]

6.1

a) Zero correlation ✔
b) A moderate negative correlation ✔
c) A strong positive correlation ✔
d) A non-linear correlation (a quadratic relationship) ✔
e) A strong negative correlation✔
f) A moderate positive correlation ✔
g) A non-linear correlation (a quadratic relationship) ✔
h) A non-linear correlation (an exponential relationship)✔

APPENDIX J: SAMPLE OF SCRIPT

UNISA college of education

Title: Teaching Strategies Used in Grade 10 to tech Data Handling.

GRADE 10

MATHEMATICS
POST- TEST
28 FEBRUARY 2023

MARKS: 50
TIME: 1 hour
Name & Surname:.....
Seat Number :.....& Row Number.....

20/50 B

Examiner: Mlambo R.R.F
Moderator: Dr Sambo T.F
Supervisor: Dr Makgakga T.P

This question paper consists of 7 pages including cover page.

INSTRUCTIONS AND INFORMATION

Read the following instructions carefully before answering the questions.

1. This question paper consists of **SIX** questions.
2. Answer ALL the questions by **filling in the space provided.**
3. Clearly show ALL calculations, diagrams, graphs, et cetera that you have used indetermining your answers.
4. You may use an approved scientific calculator (non-programmable and non-graphical), unless stated otherwise.
5. Answers only will NOT necessarily be awarded full marks.
6. If necessary, round off answers to TWO decimal places, unless stated otherwise.
7. Diagrams are NOT necessarily drawn to scale.
8. Number the answers correctly according to the numbering system used in thisquestion paper.
9. Write neatly and legibly.

Question 1 [18]

1.1 For each of the following sets of data find:

a) R2,50; R3,00; R6,50; R1,25; R6,50; R2,50; R6,50

i) The mean (2)

$\frac{28,75}{7} = R4,41$

R2,50 + R3,00 + R6,50 + R1,25 + R6,50 + R2,50 + R6,50 = 28,75

ii) The median (2)

R3,00

iii) The mode (1)

R6,50

b) 120 kg; 112 kg; 118 kg; 111 kg; 113 kg; 114 kg; 119 kg; 125 kg; 109 kg; 130 kg

iv) The mean (2)

120 + 112 + 118 + 111 + 113 + 114 + 119 + 125 + 109 + 130

= 1171 : 10 = 117,1

v) The median (2)

$\frac{114 + 118}{2} = 116$

vi) The mode (1)

No mode

09

1.2 Mr Molefe was reading the section in the 2009 Census@School that shows *Favourite Subject by Gender, Grade 8 to 12*. He was astonished at how few students in Secondary Schools in the sample chose Mathematics as their favourite subject.

In an attempt to find out if the learners in his school shared the same feelings about Mathematics, he asked a representative sample of 100 boys and 100 girls in each grade what their favourite subject was. The following table shows the results of MrMolefe's survey:

Percentage of the learners in the sample whose favourite subject is Mathematics		
Grades	**Boys**	**Girls**
8	12,2%	10,3%
9	9,8%	11,2%
10	11,1%	7,8%
11	8,3%	6,9%
12		12,5%

a) What is the mean percentage of girls in the table? (2)

10,3 + 11,2 + 7,8 + 6,9 + 12,5 = 48,7

b) Mr Molefe is still waiting for the results for the Grade 12 boys. He would like the mean for the boys in the whole sample to be 10%. What must the minimumpercentage be from the Grade 12 boys in order for Mr Molefe to get the results that he wants? (4)

5,1

1.3 A representative sample of 1 000 learners in each grade from Grades 3 to 12 was

surveyed to determine the number of boys in each grade. The mean percentage of the boys in each of the grades, from Grade 3 to Grade 11 (9 grades), is 50%. The mean percentage of the boys in each of the grades, from Grades 3 to 12 (10 grades), is 49,68%. What percentage of the learners in the Grade 12 sample are boys? **(2)**

..50 + 49,68 ÷ 2.....
..= 74,84.....

Question 2 [13]

2.1 In the 2009 Census@School survey, learners were asked to measure the length of their right foot. A group of Grade 10 learners measured the lengths of each other'sfeet and recorded the lengths obtained correct to the nearest 0,5 cm. The results aresummarised in the table below:

Length of foot (in cm)	22,5	23	23,5	24	24,5	25	25,5	26
Number of learners	2	4	6	8	10	5	3	1

a) Use the table to determine the following:

i) The value of the mode. **(2)**

.....
.....22.....

ii) The value of the median. **(2)**

.....
.....24,5.....

iii) The mean foot length. **(2)**

24 + 24,5
.....
2
.....= 24,25.....

b) What does each average tell you about the foot lengths for the group of Grade10 learners?

..they.....distance.....them.....each.....by.....two.....cm...
.....
..... **(2)**

02

2.2 The table below is adapted from Census 2011 and shows the ***unemployment rate*** of25 municipalities in the Western Cape. (The unemployment rate is the percentage ofthe total labour force that is **unemployed** but actively seeking employment and willing to work.) The rate has been rounded off to the nearest whole number.

Unemployment rate (%)	7	11	13	14	15	17	18	19	21	23	24	25	26	30
Frequency (number of municipalities)	1	3	1	4	2	1	2	1	1	3	1	2	1	1

a) Determine the mean, median and mode of the unemployment rate for the 25municipalities. **(3)**

..Mean = 7+11+11+11+13+14+14+14+15+15+17+18+18+19+21+23+23+23+24+25+25+26+30 = 23 ÷ 14 = 1.64
..Median = 17 + 1 ÷ 2 = 1.5
..Mode = 1

b) Explain what each measure of central tendency tells you about the results in the table. **(2)**

It is as Increasing or decreasing

Question 3 [06]

3.1 The table below represents the ages of the 90 people accompanying FoundationPhase learners to another primary school in Pietermaritzburg:

Age (in years) (x)	Midpoint of the interval (X)	Frequency (f)	$f.X$
$0 \leq x < 10$	5	4	
$10 \leq x < 20$	15	12	
$20 \leq x < 30$	25	25	
$30 \leq x < 40$	35	14	
$40 \leq x < 50$	45	10	
$50 \leq x < 60$	55	20	
$60 \leq x < 70$	65	5	
		n = 90	

a) Use the information given in the table to

i) Determine the modal interval **(1)**

No mode

ii) Estimate the mean age of the people accompanying a learner from theFoundation Phase. **(4)**

iii) Estimate the median age of the people accompanying a learner from theFoundation Phase.

35 ✓ **(1)**

Question 4 [05]

4.1 Johan is asked to find the five number summary for the following set of numbers:

2 23 24 12 11 23 34 12 34 12 33 19 48 25 37 38 59

Johan's answer is as follows:

2 11 12 12 12 19 23 23 24 25 33 34 34 37 38 48 59

Min = 2
Q_1 = 12
Median = 24
Q_3 = 34 or 37
Max = 59

a) Give the correct solution to the question. **(2)**

24 + 25 ÷ 2 = 24,5

14

b) Identify the mistake that Johan has made. Describe the misconception and explain to John why he is incorrect. **(3)**

1

The Q3 is 3.34

5.1 The percentages achieved by a learner for a series of mathematics tests that he wrote throughout his Grade 9 year are as follows:

35	45	50	28	39	49	55	35	56	49
43	37	28	53	55	38	47	51	30	58

a) Calculate the five number summary **(5)**

Five number summary

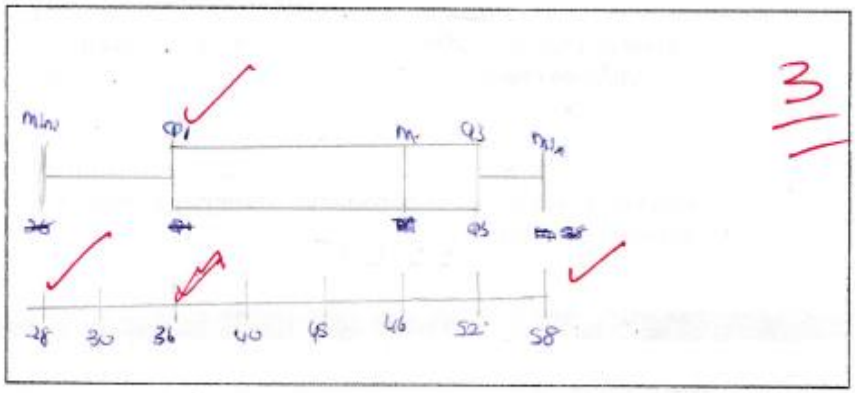
Median = 47+47 ÷ 2 = 65.5

Min = 33.37 ÷ 2 = 36

Mode = 21, 23 ÷ 2 = 52

04

b) Draw a box-and-whisker diagram to illustrate the five number summary. **(5)**



3

APPENDIX K: INTERVIEW QUESTIONS

Researcher: Rirhandzu Receive Faith Mlambo

Topic: Teaching strategies used in Grade 10 to teach data handling: A case of Bojanala district in Rustenburg.

Supervisor: _____

Participant: _____

Date: _____

Time: _____

INTERVIEW QUESTIONS

1. What do you think can be a challenge for the poor performance of the learners in concept data handling and why?
2. How do you interact with your learners during the teaching and learning of data handling?
3. Which teaching materials do you use to teach data handling?
4. What type of assessment do you use in the data handling classroom?
5. What kind of support do you give the learners with difficulties?
6. How do you establish a culture of teaching and learning in your data handling classroom?

APPENDIX L: EXAMPLE OF INTERVIEW WITH A GRADE 10 TEACHER

R- Researcher

Q- Question

P- Participant

PQ – Probing question

R: Good Afternoon

P: Good Afternoon

Question 1

R: Do you ever encounter learners who struggle with Data Handling? If so, what strategies do you use to support them?

T: Yes, some learners do find it challenging, especially when it comes to interpreting graphs or applying formulas. For these learners, I offer extra worksheets with more basic problems and sometimes hold after-school sessions. I also try to give them more hands-on activities to help reinforce the concepts.

Researcher (probing question): You mentioned using hands-on activities. Can you provide a specific example of one that has worked well for your learners?

T: Sure! One activity I use involves collecting data from their classmates on different topics, like favorite sports or hobbies. They then have to organize this data, create different types of graphs, and present their findings to the class. This helps them see the practical application of the material and keeps them engaged.

Researcher (probing question): How do you ensure that these activities are inclusive and cater to different learning styles?

T: I try to incorporate a variety of tasks—visual, auditory, and kinesthetic. For example, some learners might prefer organizing the data visually, while others might like presenting the results verbally. I also allow learners to work in pairs or groups, which helps them support each other.

Question 2

R: Thank you for agreeing to this interview. Today, I'd like to focus on how you interact with your learners during the teaching of Data Handling in Grade 10. Could you start by explaining how you engage with your learners during lessons?

T: Thank you for having me. When I teach Data Handling, I try to create an interactive environment. I like to ask a lot of questions during the lesson to check their understanding and to keep them engaged. I also encourage learners to ask questions, no matter how small, to create an open dialogue.

Question 3

R: Great approach! Do you use any specific teaching materials or resources when teaching Data Handling concepts in class?

T: Yes, I use a combination of textbooks, interactive software, and online resources like educational videos. I also create worksheets that focus on practical examples of data, such as survey results or scientific data, which I find helps learners grasp abstract concepts more easily.

R: Could you elaborate on how you use the interactive software? What role does it play in enhancing learners' understanding?

T: The software I use allows learners to visualize data through graphs and charts. For instance, after inputting a dataset, they can generate different types of graphs and see how the representation changes based on the data. This visual element helps them understand concepts like central tendency, variance, and probability.

Question 4

R: Could you describe the role that assessments or exercises play in your strategy? How do you gauge whether learners have grasped the material?

T: I use a combination of formative and summative assessments. After teaching a concept, I often give short quizzes or ask learners to solve problems in class. This gives me a sense of their understanding before moving on. I also encourage peer teaching, where stronger learners explain concepts to their peers. These allow me to gauge how well learners are grasping the material. For summative assessments, I use end-of-unit tests and projects where they have to analyze data sets and present their findings. I also encourage learners to reflect on their learning, which gives me insight into their thought processes.

Question 5

R: Do you ever encounter learners who struggle with Data Handling? If so, what strategies do you use to support them?

T: Yes, some learners do find it challenging, especially when it comes to interpreting graphs or applying formulas. For these learners, I offer extra worksheets with more basic problems and sometimes hold after-school sessions. I also try to give them more hands-on activities to help reinforce the concepts.

Researcher (probing question): You mentioned using hands-on activities. Can you provide a specific example of one that has worked well for your learners?

plain concepts to their peers.

T: Differentiation is key. For learners who struggle, I use step-by-step scaffolding, where we break down the concepts into smaller, manageable parts. I also use collaborative learning, where learners work in groups and help each other. More advanced learners can take on leadership roles in group activities, helping others while reinforcing their own understanding.

I also incorporate a lot of hands-on activities like surveys or data collection exercises to keep all learners engaged.

Question 6

R: That's a great strategy. Moving on to classroom culture, how do you establish a culture of teaching and learning that supports active engagement with topics like Data Handling?

T: Creating a positive learning environment is critical. I focus on building respect and mutual trust in the classroom. From the beginning of the year, I set clear expectations about participation and behavior. I also use positive reinforcement, such as praising good work and rewarding group efforts with small incentives. Making learning relevant to real-life situations is another approach—I use real-world data sets to show how the concepts apply outside the classroom.

Researcher (probing question): Could you give me an example of a real-life data set you've used?

T: One example is using data from surveys on learner interests or local community issues. We analyzed a data set on environmental awareness in our community and created charts to display the results. Learners really enjoyed this because it connected the math to something tangible in their lives.

Researcher (probing question): That's a great example of personalized support. Shifting gears a bit, how do you establish a culture of teaching and learning in your classroom, especially when working on a topic like Data Handling?

T: Establishing a learning culture is very important to me. I create an environment where questions are encouraged, and mistakes are seen as part of the learning process. I make it clear from the start that participation is key. Learners know they can ask for help at any time, and I try to build a classroom where they feel comfortable working together and learning from one another.

Question 7

R: Thank you for your insights. Finally, how do you keep the learners motivated when learning about Data Handling?

T: Motivation is key. I try to make the content relevant by relating it to their interests, like using data from sports, social media, or other areas that matter to them. I also use gamification—turning some exercises into challenges or competitions. Celebrating small victories helps, too. When learners see their progress, they're more likely to stay engaged and motivated.

R: That's great! Thank you for your time and for sharing your strategies with me.

T: You're welcome! I'm always happy to talk about teaching experience.

APPENDIX M: OBSERVATION SCHEDULE

Researcher: Rirhandzu Receive Faith Mlambo

Topic: Teaching strategies used in grade 10 to teach data handling: A case of Bojanala district in Rustenburg.

Supervisor: _____

Participant: _____

Date: _____

Time: _____

Lesson observation 1: The researcher will observe the following from the teacher's lesson:

How teaching and learning in mathematics classroom takes place?

The types of teaching strategies used during teaching.

The questions used to guide the learners towards the lesson involvement and assessment used.

How teachers accommodate learners who experience learning barriers.

The purpose of assessing learners during or after the lesson.

The type of resources used during teaching and learning.

Lesson observation 2: The researcher will observe the following during teaching and learning:

How effectively do teachers apply the teaching strategies in the classrooms?

How the teachers handle learners' responses from the questions asked.

The interaction between teachers and learners; and amongst the learners during teaching and learning.

How teachers support learners who experience some difficulties during teaching and learning?

How learners behave towards each other during teaching and learning?

How effective are all learners involved during teaching and learning?

How the teacher (especially in the experimental group) applies the intervention strategies in the classroom?

APPENDIX N: STATISTICAL RESULTS FOR PRE-TEST AND POST-TEST

Excel was used or data management, Stata Release 15 and and SPSS for data analysis. T-test was used to compare the two study groups, the experimental and the control groups. In other words, the results were declared significant if the p-value was less than 0.05.

Note: If p < 0.05 Results are significant

If p ≥0.05 then the results are not significant

Output Created	13-FEB-2024 11:51:08
Comments	**Results were declared significant**

Two-sample t test with equal variance

T-Test comparison for Pre and Post-test from Q1-Q6 for CG only

Paired Samples Statistics

		Mean	N	Std. Dev	Std. Error Mean
Question 1	Post-Test CG	5,43	30	1,591	0,290
	Pre-Test CG	2,07	30	1,818	0,332
Question 2	Post-Test CG	3,87	30	1,306	0,238
	Pre-Test CG	2,33	30	1,918	0,350
Question 3	Post-Test CG	2,07	30	0,785	0,143
	Pre-Test CG	3,13	30	2,909	0,531
Question 4	Post-Test CG	1,47	30	0,507	0,093
	Pre-Test CG	0,80	30	1,243	0,227
Question 5	Post-Test CG	2,60	30	1,522	0,278
	Pre-Test CG	2,37	30	1,921	0,351
Question 6	Post-Test CG	0,83	30	0,747	0,136
	Pre-Test CG	0,93	30	0,980	0,179

T-Test difference between Pre and Post-test from Q1-Q6 for CG only

Paired Samples Correlations					
				Significance	
		N	Correlation	One-Sided p	Two-Sided p
Question 1	Pre-Post CG	30	-0,034	0,429	0,858
Question 2	Pre-Post CG	30	0,280	0,067	0,134
Question 3	Pre-Post CG	30	0,117	0,269	0,539
Question 4	Pre-Post CG	30	-0,011	0,477	0,954
Question 5	Pre-Post CG	30	-0,019	0,461	0,921
Question 6	Pre-Post CG	30	-0,204	0,140	0,279

T-Test for Pre and Post-test from Q1-Q6 for CG only

Paired Samples Test					
		Paired Differences			
		Mean	Std.Dev	Std. Error Mean	95% Conf Lower
Question 1	Pre-Post CG	3,367	2,456	0,448	2,449
Question 2	Pre-Post CG	1,533	1,995	0,364	0,788
Question 3	Pre-Post CG	-1,067	2,924	0,534	-2,158
Question 4	Pre-Post CG	0,667	1,348	0,246	0,163
Question 5	Pre-Post CG	0,233	2,473	0,452	-0,690
Question 6	Pre-Post CG	-0,100	1,348	0,246	-0,603

T-Test one-sided for Pre and Post-test from Q1-Q6 for CG only

Paired Samples Test					
		Paired Differences			Significance
		95% Conf Upper	t	df	One-Sided p
Question 1	Pre-Post CG	4,284	7,507	29	<,001
Question 2	Pre-Post CG	2,278	4,209	29	<,001
Question 3	Pre-Post CG	0,025	1,998	29	0,028

Question 4	Pre-Post CG	1,170	2,710	29	0,006
Question 5	Pre-Post CG	1,157	0,517	29	0,305
Question 6	Pre-Post CG	0,403	-0,406	29	0,344

T-Test two-sided for Pre and Post-test from Q1-Q6 for CG only

Paired Samples Test		
		Significance
		Two-Sided p
Question 1	Pre-Post test CG	<,001
Question 2	Pre-Post test CG	<,001
Question 3	Pre-Post test CG	0,055
Question 4	Pre-Post test CG	0,011
Question 5	Pre-Post test CG	0,609
Question 6	Pre-Post test CG	0,687

T-Test comparison for Pre and Post-test from Q1-Q6 for EG only

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Question 1	Post EG	5,13	30	1,479	0,270
	Pre EG	2,40	30	1,773	0,324
Question 2	Post EG	4,93	30	2,050	0,374
	Pre EG	1,63	30	1,377	0,251
Question 3	Post EG	2,83	30	1,147	0,209
	Pre EG	3,23	30	2,445	0,446
Question 4	Post EG	2,03	30	1,033	0,189
	Pre EG	0,80	30	0,805	0,147
Question 5	Post EG	2,83	30	1,949	0,356
	Pre EG	0,87	30	1,074	0,196
Question 6	Post EG	1,20	30	1,095	0,200
	Pre EG	0,73	30	0,868	0,159

T-Test correlation for Pre and Post-test from Q1-Q6 for EG only

Paired Samples Correlations					
				Significance	
		N	Correlation	One-Sided p	Two-Sided p
Question 1	Pre-Post EG	30	-0,152	0,211	0,421
Question 2	Pre-Post EG	30	-0,131	0,245	0,490
Question 3	Pre-Post EG	30	0,334	0,036	0,071
Question 4	Pre-Post EG	30	-0,116	0,271	0,541
Question 5	Pre-Post EG	30	0,104	0,292	0,583
Question 6	Pre-Post EG	30	0,239	0,101	0,203

T-Test difference for Pre and Post-test from Q1-Q6 for EG only

Paired Samples Test					
		Paired Differences			
		Mean	Std. Deviation	Std. Error Mean	95% Conf Lower
Question 1	Pre EG	2,733	2,477	0,452	1,809
Question 2	Pre EG	3,300	2,615	0,477	2,324
Question 3	Pre EG	-0,400	2,328	0,425	-1,269
Question 4	Pre EG	1,233	1,382	0,252	0,717
Question 5	Pre EG	1,967	2,125	0,388	1,173
Question 6	Pre EG	0,467	1,224	0,224	0,010

T-Test one-sided for Pre and Post-test from Q1-Q6 for EG only

Paired Samples Test					
		Paired Differences			Significance
		95% Conf Upper	t	df	One-Sided p
Question 1	Post EG	3,658	6,045	29	<,001
Question 2	Post EG	4,276	6,912	29	<,001

Question 3	Post EG	0,469	-0,941	29	0,177
Question 4	Post EG	1,749	4,889	29	<,001
Question 5	Post EG	2,760	5,069	29	<,001
Question 6	Post EG	0,924	2,088	29	0,023

T-Test Groups comparison on Pre and Post-test for EG & CG

Variables to Cases for EG and CG Comparisons

Group Statistics

	Group	N	Mean	Std. Dev	Std. Error Mean
Pre-Test	CG	30	11,6333	7,23728	1,32134
	EG	30	9,6667	6,01340	1,09789
Post-Test	CG	30	16,2667	3,56161	0,65026
	EG	30	18,9667	5,42334	0,99016

T-Test Groups comparison on Q1 Pre and Post-test for EG & CG

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pre Q1	CG	30	2,07	1,818	0,332
	EG	30	2,40	1,773	0,324
Post Q1	CG	30	5,43	1,591	0,290
	EG	30	5,13	1,479	0,270

T-Test Groups correlation on Q1 Pre and Post-test for EG & CG

Paired Samples Correlations

Group			N	Correlation	Significance	
					One-Sided p	Two-Sided p
CG	Question 1	Pre & Post	30	-0,034	0,429	0,858
EG	Question 1	Pre & Post	30	-0,152	0,211	0,421

T-Test Groups significance on Q1 Pre and Post-test for EG & CG

Paired Samples Test											
			Paired Differences							Significance	
						95% Confidence					
Group			Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
CG	Q=1	Pre & Post	-3,367	2,456	0,448	-4,284	-2,449	-7,507	29	<,001	<,001
EG	Q=1	Pre & Post	-2,733	2,477	0,452	-3,658	-1,809	-6,045	29	<,001	<,001

T-Test Groups comparison on Q2 Pre and Post-test for EG & CG

Paired Samples Statistics						
Group			Mean	N	Std. Deviation	Std. Error Mean
CG	Question 2	Pre	2,33	30	1,918	0,350
		Post	3,87	30	1,306	0,238
EG	Question 2	Pre	1,63	30	1,377	0,251
		Post	4,93	30	2,050	0,374

T-Test Groups significance on Q2 Pre and Post-test for EG & CG

Paired Samples Correlations						
					Significance	
Group			N	Correlation	One-Sided p	Two-Sided p
CG	Question 2	Pre & Post	30	0,280	0,067	0,134
EG	Question 2	Pre & Post	30	-0,131	0,245	0,490

T-Test Groups significance on Q2 Pre and Post-test for EG & CG

Paired Samples Test											
			Paired Differences							Significance	
						95% Confidence					
Group			Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
CG	Q=2	Pre & Post	-1,533	1,995	0,364	-2,278	-0,788	-4,209	29	<,001	<,001
EG	Q=2	Pre & Post	-3,300	2,615	0,477	-4,276	-2,324	-6,912	29	<,001	<,001

T-Test Groups on Q3 Pre and Post-test for EG & CG

Paired Samples Statistics

Group			Mean	N	Std. Deviation	Std. Error Mean
CG	Question 3	Pre	3,13	30	2,909	0,531
		Post	2,07	30	0,785	0,143
EG	Question 3	Pre	3,23	30	2,445	0,446
		Post	2,83	30	1,147	0,209

T-Test Groups on Q3 Pre and Post-test for EG & CG

Paired Samples Test

			Paired Differences							Significance	
						95% Confidence					
Group			Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
CG	Q=3	Pre & Post	1,067	2,924	0,534	-0,025	2,158	1,998	29	0,028	0,055
EG	Q=3	Pre & Post	0,400	2,328	0,425	-0,469	1,269	0,941	29	0,177	0,354

T-Test Groups significance on Q4 Pre and Post-test for EG & CG

Paired Samples Statistics

Group			Mean	N	Std. Deviation	Std. Error Mean
CG	Question 4	Pre	0,80	30	1,243	0,227
		Post	1,47	30	0,507	0,093
EG	Question 4	Pre	0,80	30	0,805	0,147
		Post	2,03	30	1,033	0,189

T-Test Groups significance on Q4 Pre and Post-test for EG & CG

Paired Samples Correlations

Group			N	Correlation	Significance	
					One-Sided p	Two-Sided p
CG	Question 4	Pre & Post	30	-0,011	0,477	0,954
EG	Question 4	Pre & Post	30	-0,116	0,271	0,541

T-Test Groups significance on Q4 Pre and Post-test for EG & CG

Paired Samples Test

Group			Paired Differences					t	df	Significance	
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Lower	95% Confidence Upper			One-Sided p	Two-Sided p
CG	Q=4	Pre & Post	-0,667	1,348	0,246	-1,170	-0,163	-2,710	29	0,006	0,011
EG	Q=4	Pre & Post	-1,233	1,382	0,252	-1,749	-0,717	-4,889	29	<,001	<,001

T-Test Groups significance on Q5 Pre and Post-test for EG & CG

Paired Samples Statistics

Group			Mean	N	Std. Deviation	Std. Error Mean
CG	Question 5	Pre	2,37	30	1,921	0,351
		Post	2,60	30	1,522	0,278
EG	Question 5	Pre	0,87	30	1,074	0,196
		Post	2,83	30	1,949	0,356

T-Test Groups significance on Q5 Pre and Post-test for EG & CG

Paired Samples Test

Group			Paired Differences					t	df	Significance	
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Lower	95% Confidence Upper			One-Sided p	Two-Sided p
CG	Q=5	Pre & Post	-0,233	2,473	0,452	-1,157	0,690	-0,517	29	0,305	0,609
EG	Q=5	Pre & Post	-1,967	2,125	0,388	-2,760	-1,173	-5,069	29	<,001	<,001

T-Test Groups significance on Q6 Pre and Post-test for EG & CG

Paired Samples Statistics

Group			Mean	N	Std. Deviation	Std. Error Mean
CG	Question 6	Pre	0,93	30	0,980	0,179
		Post	0,83	30	0,747	0,136
EG	Question 6	Pre	0,73	30	0,868	0,159

		Post	1,20	30	1,095	0,200

T-Test Groups comparison on Q6 Pre and Post-test for EG & CG

Paired Samples Correlations						
Group			N	Correlation	Significance	
					One-Sided p	Two-Sided p
CG	Question 6	Pre & Post	30	-0,204	0,140	0,279
EG	Question 6	Pre & Post	30	0,239	0,101	0,203

T-Test Groups significance on Q6 Pre and Post-test for EG & CG

Paired Samples Test										
Group			Paired Differences					t	df	Significance	
			Mean	Std. Deviation	Std. Error Mean	95% Confidence				One-Sided p	Two-Sided p
						Lower	Upper				
CG	Q = 6	Pre & Post	0,100	1,348	0,246	-0,403	0,603	0,406	29	0,344	0,687
EG	Q = 6	Pre & Post	-0,467	1,224	0,224	-0,924	-0,010	-2,088	29	0,023	0,046

T-Test Groups significance on Q1-Q6 Pre & Post-test for EG & CG

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
Pre = Q1	CG	30	2,07	1,818	0,332
	EG	30	2,40	1,773	0,324
Pre = Q2	CG	30	2,33	1,918	0,350
	EG	30	1,63	1,377	0,251
Pre = Q3	CG	30	3,13	2,909	0,531
	EG	30	3,23	2,445	0,446
Pre = Q4	CG	30	0,80	1,243	0,227
	EG	30	0,80	0,805	0,147
Pre = Q5	CG	30	2,37	1,921	0,351
	EG	30	0,87	1,074	0,196
Pre = Q6	CG	30	0,93	0,980	0,179
	EG	30	0,73	0,868	0,159
Sum	CG	30	11,6333	7,23728	1,32134

	EG	30	9,6667	6,01340	1,09789

T-Test Groups comparison on Q1-Q6 Pre and Post-test for EG & CG

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Post = Q1	CG	30	5,43	1,591	0,290
	EG	30	5,13	1,479	0,270
Post = Q2	CG	30	3,87	1,306	0,238
	EG	30	4,93	2,050	0,374
Post = Q3	CG	30	2,07	0,785	0,143
	EG	30	2,83	1,147	0,209
Post = Q4	CG	30	1,47	0,507	0,093
	EG	30	2,03	1,033	0,189
Post = Q5	CG	30	2,60	1,522	0,278
	EG	30	2,83	1,949	0,356
Post = Q6	CG	30	0,83	0,747	0,136
	EG	30	1,20	1,095	0,200
Sum	CG	30	16,2667	3,56161	0,65026
	EG	30	18,9667	5,42334	0,99016

APPENDIX O: EDITING CERTIFICATE

Unit 3 West Square Business Park
407 West Avenue
Randburg
2194

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6 February 2025

TO WHOM IT MAY CONCERN

This serves to confirm that I have edited and made the necessary corrections and emendations to the study:

STRATEGIES USED TO TEACH GRADE 10 DATA HANDLING: A CASE OF BOJANALA DISTRICT IN RUSTENBURG

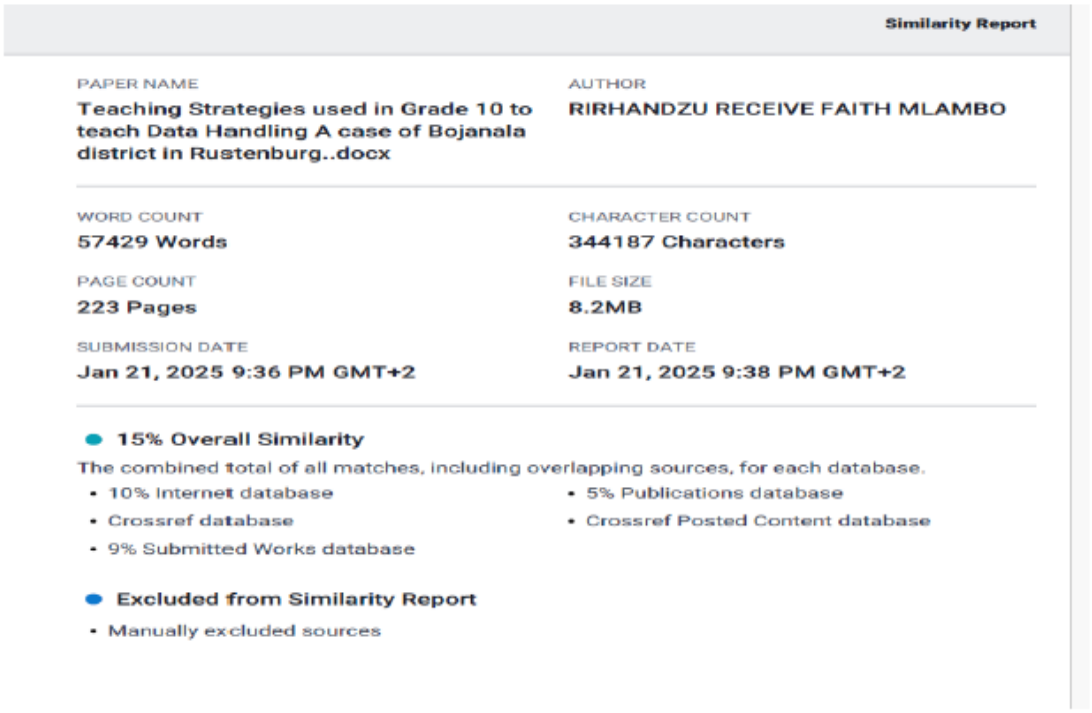
by

RIRHANDZU RECEIVE FAITH MLAMBO

Sincerely

J Musi
Editor

APPENDIX P: TURNITIN REPORT



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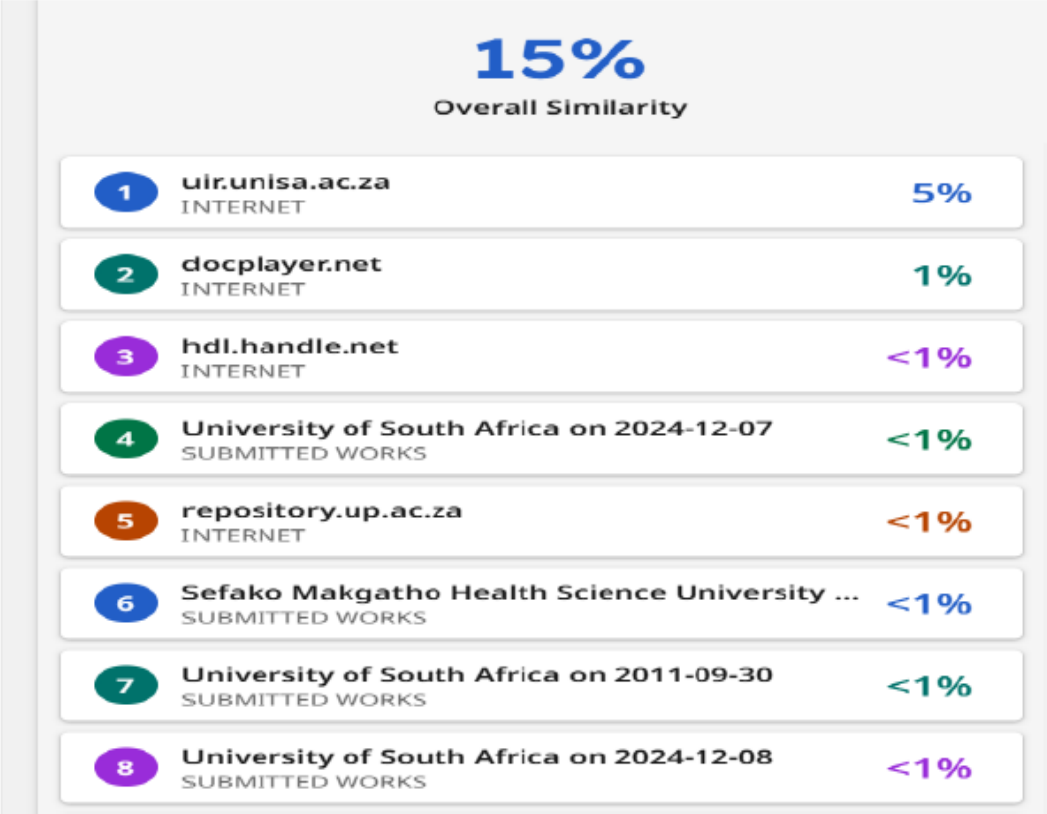

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