Mathematical Literacy teachers' strategies to engage with learners' misconceptions and errors in the teaching of Measurement in Grade 12

by

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DECLARATION

This thesis is submitted in complete fulfilment of the requirements for the degree of Doctor of Philosophy at the Graduate Programme in Mathematics Education of the School of Education in the Faculty of Humanities at the University of KwaZulu-Natal, in Pietermaritzburg, South Africa.

I, Lebohang Victoria Mulaudzi, student number 223153392, declare that:

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DEDICATION

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LIST OF ABBREVIATIONS

CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
FET	Further Education Training
FSDoE	Free State Department of Education
HoD	Heads of Department
HSSREC	Humanities and Social Science Research Ethics Committee
MKO	More Knowledgeable Other
ML	Mathematical Literacy
PM	Pure Mathematics
RQ	Research Question
TM	Technical Mathematics
UKZN	University of KwaZulu-Natal
ZPD	Zone of Proximal Development

ABSTRACT

This study investigated the remedial strategies used by Grade 12 Mathematical Literacy teachers in South Africa to address learners' misconceptions and errors in the topic of Measurement. Persistent underperformance in Measurement, as reflected in national diagnostic reports, highlights an urgent need for pedagogical interventions that move beyond procedural correction and promote conceptual understanding. Rooted in constructivist theory, particularly the work of Piaget and Vygotsky, the study views misconceptions not as isolated mistakes but as evidence of prior knowledge that must be reconstructed through guided interaction, contextualised learning, and scaffolded teaching. The research adopted an interpretivist paradigm and employed a qualitative, exploratory case study design involving six purposively and conveniently selected Mathematical Literacy teachers from the Motheo District in the Free State province. Data were generated through semi-structured interviews, classroom observations, and document analysis, which included samples of learners' work and the diagnostic reports of the Department of Basic Education. Findings revealed four recurring categories of errors and misconceptions: procedural, computational, conceptual, and challenges interpreting and applying Measurement in real-life contexts such as time, scale, and surface area. These 'dual-layer' errors combined surface-level mistakes with deeper conceptual gaps. Teachers' engagement with learners' errors varied. Some teachers employed scaffolded instruction, diagnostic assessment, hands-on activities, and peer collaboration to identify and correct misconceptions. Others relied on procedural correction due to time pressure, curriculum pacing demands, large classes, limited resources, or insufficient content knowledge. The study found that teachers' emotional connection to the subject, confidence, and professional identity shaped whether they engaged meaningfully with misconceptions. Teachers who felt disconnected from Mathematical Literacy were less inclined to invest in remediation. The study concludes that improving learners' outcomes in Measurement requires a shift toward constructivist, concept-driven pedagogy supported by systemic conditions that enable diagnostic teaching. Recommendations include professional development to enable teachers to identify and address misconceptions, learn reflective practice tools (e.g., teacher journaling, peer observation), and build subject affinity and pedagogical skills. Teacher education programmes should model how to analyse learner errors, trace their conceptual roots, and scaffold understanding through targeted intervention.

Keywords: mathematical literacy, measurement misconceptions, remedial strategies, constructivist pedagogy, teacher engagement

CHAPTER 1: ORIENTATION TO THE STUDY

1.1 Introduction

Mathematical Literacy (ML) occupies a central role in the South African curriculum as a subject designed to equip learners with the ability to apply mathematical reasoning to real-life situations (DBE, 2011; Sumirattana et al., 2017). Despite this intention, national performance data and diagnostic reports continue to reveal persistent underperformance by learners in the topic of Measurement, which now carries the highest weighting in the Grade 12 ML examination (DBE, 2021; DBE, 2022; DBE, 2023). Learners' consistent repetition of the same errors and misconceptions on their national exam scripts suggests deep-seated conceptual difficulties that are not resolved through procedural teaching alone (DBE, 2021; DBE, 2022; DBE, 2023). This study investigates the remedial strategies used by Grade 12 Mathematical Literacy teachers to address learners' errors and misconceptions in Measurement. The research was conducted in the Motheo District of the South African province of the Free State. It involved six teachers whose instructional practices were explored through interviews, lesson observations, and document analysis. By focusing specifically on Measurement, the study responds to an area of the curriculum where learners' underperformance is both historically documented and pedagogically consequential.

This chapter introduces and orients the study by outlining the background and context of Mathematical Literacy in South Africa, the problem of learners' misconceptions in Measurement, and the purpose, aims, objectives, and research questions guiding the inquiry. The chapter also presents an overview of the research paradigm, approach, and design and explains the significance, limitations, and key terminology of the study. It concludes with a brief outline of the thesis structure itself, establishing a foundation for the chapters that follow.

1.2 Background of the study

The South African basic education system offers three streams for mathematics: Pure Mathematics, Mathematical Literacy, and Technical Mathematics (Machaba & Mwakapenda, 2017; Venkatakrishnan & Graven, 2006). According to the Curriculum and Assessment Policy Statement (CAPS) (DBE, 2011), Pure Mathematics is a language that describes numerical, geometric, and pictorial relationships using symbols and notations. It develops logical reasoning, accuracy, problem-solving, and decision-making skills and helps learners make sense of the physical, social, and economic world (DBE, 2011).

Technical Mathematics, introduced in 2016, applies mathematical science to technical contexts, supporting subjects such as civil, electrical, and mechanical engineering (DBE, 2014). It focuses on computational skills, mathematical modelling, and the 'when' and 'why' of problem types, preparing learners for artisan careers or further study at FET Colleges (DBE, 2014).

Mathematical Literacy (ML) was introduced to provide an alternative for learners who struggle with Pure Mathematics, while still recognising the importance of mathematical reasoning in everyday life (Brown & Schäfer, 2006; Jojo, 2019). Unlike Pure Mathematics and Technical Mathematics, Mathematical Literacy emphasises the practical application of mathematical knowledge in authentic contexts such as financial decision-making, data handling, and spatial reasoning (DBE, 2011; Sumirattana et al., 2017; Afni, 2020). The subject equips learners to function effectively in a world increasingly driven by numbers, data, and quantitative arguments (DBE, 2011). It fosters reasoning, decision-making, problem-solving, information interpretation, resource management, and technology use (DBE, 2011; Sumirattana et al., 2017).

Despite its relevance, the teaching and learning of Mathematical Literacy face challenges such as limited resources, overcrowded classrooms, and varying teacher expertise (Graven & Buytenhuys, 2011; Tachie, 2020; Tewari & Ilesanmi, 2020). Learners' persistent errors and misconceptions, especially in the topic of Measurement, continue to hinder their performance (Tan Sisman & Aksu, 2016).

1.2.1 Measurement in Mathematical Literacy

Measurement forms part of the 'Space, Shape and Measurement' learning area in the South African Mathematical Literacy curriculum (DBE, 2011). It equips learners with practical skills for solving real-life problems involving length, area, volume, unit conversions, and related applications (Botha et al., 2023). However, the concepts involved are cognitively demanding, requiring spatial reasoning, estimation, the use of standard units, and precision (Smith et al., 2016). Learners often struggle to link abstract measurement concepts to real-world situations, leading to recurring errors and misconceptions (Tan Sisman & Aksu, 2016; Jamaludin & Maat, 2020).

Common misconceptions include misunderstanding the relationship between units, misinterpreting precision, and conflating measurement with arithmetic operations (Yun et al.,

2016). These misconceptions persist even after instruction, indicating that procedural teaching alone is insufficient (Jamaludin & Maat, 2020).

1.2.2 Errors, misconceptions, and the role of teachers

Errors refer to incorrect answers caused by calculation slips or misapplication of known concepts, whereas misconceptions reflect deeper, persistent misunderstandings of concepts (Mutambara & Bansilal, 2022). For example, a learner may know the formula for area but miscalculate repeatedly due to an underlying misconception that doubling a shape's side length doubles its area. In this way, repeated errors may reveal underlying misconceptions (Mutambara & Bansilal, 2022).

Teachers therefore play a central role in identifying, interpreting, and remediating such misconceptions. The CAPS and DBE diagnostic reports emphasise that teachers should not only teach content but also actively engage with learners' errors to support conceptual understanding (Royal & Kiesow, 2021). Effective teaching requires creating safe learning environments where learners can express misunderstandings, supported by strategies that correct and prevent misconceptions (Singh et al., 2019). Without such strategies, misconceptions become cumulative and hinder learners' mathematical development (Kurudirek et al., 2025; Jankvist & Niss, 2018).

1.2.3 **Weighting and importance of Measurement**

Although Mathematical Literacy covers several content areas, Measurement demands particular attention due to its high examination weighting, persistent underperformance, and centrality to real-life problem solving. The weighting table below shows that Measurement carries a significantly larger share of marks in the Grade 12 final examination than most other topics.

Figure 1

DBE topic weighting (2021:3)

WEIGHTING

CAPS				**NEW 2021 changes**		
		%	300-mark paper		%	150-mark paper
PAPER 1 and 2 COMBINED	Finance	±35%	**105**	**PAPER 1**	60%	90
	Data	±25%	75		35%	53
	Probability	5%	7		5%	7
					100%	**150 marks**
	Measurement	±20%	60	**PAPER 2**	55 %	83**
	Maps and plans	±15%	45		40%	60**
	Probability	5%	8		5%	7
	Finance **					
	TOTAL				**100%**	**150 marks**

****NOTE:**

- Section in Finance: (Income, Expenditure, Profit/Loss, Income-and-Expenditure statements and Budgets, Cost Price and Selling Price) can be included in PAPER 2 where there is direct link to Measurement and Maps and Plans.
- Growth Charts can be examined in Data Handling in PAPER 1, as it assesses application of measures of spread.

In the Grade 12 curriculum, Measurement used to account for 20% (60 marks) of a 300-mark paper. Following the 2021 revision, its weighting increased to 55% (83 marks) in Paper 2 alone, making it the single most dominant topic (DBE, 2021). This shift reflects the DBE's recognition of Measurement as essential for authentic mathematical literacy, including applications such as calculating perimeter and surface area for construction, converting units in domestic and business settings, interpreting scale drawings, and solving time-distance problems. Given that more than half of Paper 2 assesses Measurement, learner' errors in this topic can drastically lower their overall performance, contributing to declining pass and distinction rates in ML (DBE, 2022; 2023).

Although ML includes several content areas such as finance, data handling, and probability, this study focuses specifically on Measurement because it represents one of the most conceptually demanding and integrative domains within the curriculum. Measurement tasks require learners to combine multiple mathematical competencies, including unit conversions, proportional reasoning, spatial reasoning, interpretation of scale, and arithmetic operations. As such, errors in Measurement often reveal deeper conceptual misunderstandings rather than isolated procedural mistakes. Furthermore, the topic carries the highest weighting in the Grade 12 examination and consistently appears in DBE diagnostic reports as an area of persistent

learner difficulty. For these reasons, Measurement provides a useful paradigmatic case for investigating misconceptions in Mathematical Literacy. By examining how teachers identify and remediate errors within this domain, the study generates insights that may be analytically transferable to other areas of the subject where similar conceptual challenges arise.

Despite recurring diagnostic evidence of learners' weaknesses in Measurement, there is limited empirical research on how ML teachers actually address these errors and misconceptions in Grade 12 classrooms, where examination pressure is highest. The study therefore responds to a curriculum-driven, performance-driven, and pedagogically-driven problem by exploring the remedial strategies that Mathematical Literacy teachers employ to address learners' errors and misconceptions in Measurement in Grade 12.

1.3 Purpose of the study

The study aims to explore the remedial strategies Mathematical Literacy teachers employ to address learners' errors and misconceptions in Measurement in Grade 12. By exploring these strategies, the study aims to identify common misconceptions and errors exhibited by learners, evaluate how teachers engage with these misconceptions and errors, and determine the reasons behind teachers' engagement or lack thereof. The goal is to enhance teaching practices and improve learning outcomes in Mathematical Literacy by providing insights and practical solutions that teachers, departments and schools can adopt to effectively address learners' challenges in Measurement.

1.4 Context of the study

The study was conducted in the Motheo District of the Free State province of South Africa, a region characterised by a diverse population and significant socio-economic challenges (Nkadimeng, 2025). Approximately 90% of the population resides in urban areas, while 10% lives in rural areas. Poverty levels are high, with unemployment rates reaching 40% in Mangaung, 36% in Mantsopa, and 37% in Naledi. Primary economic activities in the district include the service sector in urban areas such as Bloemfontein and agriculture in rural regions like Mantsopa and Naledi (Marais & Cloete, 2016; Meyer, 2016).

This socio-economic and educational context provided a valuable setting for exploring how Mathematical Literacy teachers address learner misconceptions in Measurement. Learners in such contexts often face resource limitations, uneven learning opportunities, and diverse lived experiences that shape their understanding of mathematical concepts. Teachers working in

these settings must frequently adapt their instructional strategies to bridge gaps in foundational knowledge, contextualise abstract concepts, and respond to varied learning needs. These contextual dynamics make the district a rich site for examining how teachers identify and remediate misconceptions in practical, real-world classroom conditions.

1.5 Problem statement

This study investigates the remedial strategies used by Grade 12 Mathematical Literacy teachers to address learner misconceptions in Measurement. National performance data shows a concerning decline: in 2023, only 2.2% of learners achieved a distinction in Mathematical Literacy, and just 56.7% passed with 40% or more, compared to 60.4% in 2022 (DBE, 2022; 2023). DBE reports (2022; 2023) and an exam guideline (2021) indicate that Paper 2, which now allocates 55% of its marks (around 83 of 150 marks) to Measurement, recorded the lowest average scores, indicating that misconceptions in this topic are a major contributor to overall learner underperformance. Although the DBE (2022; 2023) recommends that teachers use the Department's diagnostic reports to implement remedial strategies, there is limited empirical evidence on how teachers actually engage with learners' errors in Measurement, or why some do not do so. The problem, therefore, is not only that learners consistently struggle with Measurement, but that insufficient knowledge exists about the pedagogical responses teachers use to remediate these misconceptions in Grade 12 classrooms.

1.6 Theoretical framework

Constructivism was chosen as the theoretical framework for this study, providing a robust foundation for understanding how teachers engage with learner's construction of knowledge, develop their conceptual understanding, and engage in remediation when addressing learners' misconceptions in Measurement. Constructivism posits that misconceptions are not merely errors but can be used meaningful entry points for instruction, where teachers can facilitate conceptual change through guided exploration, reflection, and dialogue. This study explores whether teachers use scaffolding in their teaching of measurement concepts, focusing on how teachers engage with learners' prior knowledge, which includes their personal experiences and social interactions (Kalpana, 2014; Main, 2021; Tanjung et al., 2023; Bruner, 1966; Golder & Bengal, 2018; Piaget,1977; Vygotsky, 1978; cf. chapter 4). The choice of constructivism as the theoretical framework for this study facilitated a nuanced understanding of effective remedial strategies and instructional interventions used by teachers to address learners' misconceptions.

1.7 Research aim and objectives

This study aimed to explore the remedial strategies that Mathematical Literacy teachers employ to address learners' errors and misconceptions in Measurement in Grade 12.

The objectives were as follows:

1. to identify the common misconceptions and errors that learners exhibit in Measurement in Mathematical Literacy.

2. to explore how Mathematical Literacy teachers engage with learners' misconceptions and errors in Measurement.

3. to determine why Mathematical Literacy teachers engage, or not engage, with learners' errors and misconceptions.

1.8 Research question and sub-research questions

The main research question that guided this study is:

> What remedial strategies do Mathematical Literacy teachers employ to address learners' errors and misconceptions in Measurement in Grade 12?

The following research sub-questions were used to answer this question:

1. What are the common misconceptions and errors that learners exhibit in Measurement in Mathematical Literacy?

2. How do Mathematical Literacy teachers engage with learners' misconceptions and errors in Measurement?

3. Why do Mathematical Literacy teachers engage or not engage with learners' errors and misconceptions?

1.9 Overview of the research methodology

This section presents an overview of the methodology. A research methodology directs the researcher's study design to address the research topic and achieve the study's goals and objectives (Nayak & Singh, 2021). This study was grounded in an interpretivist paradigm, which assumes that reality is socially constructed and that meaning is shaped by the

experiences and perspectives of individuals (Fasoli, 2020; Saunders et al., 2019). This paradigm is appropriate because learners' misconceptions in Measurement are not merely technical errors, but are influenced by personal, cultural, and classroom contexts; therefore, understanding them requires an exploration of teachers' interpretations rather than measurement through numerical data.

A qualitative research approach was adopted to allow for an in-depth examination of how teachers recognised and responded to learners' misconceptions, as well as how these responses were shaped by their instructional practices and beliefs. Since the study is to generate rich, contextualised insights rather than generalisable statistics, a qualitative case study design was most suitable (Greckhamer & Cilesiz, 2022). The study was conducted in the Motheo District of the Free State Province, focusing specifically on Grade 12 Mathematical Literacy teachers who teach the topic of Measurement. The case study design made it possible to explore the complexity of teachers' remedial strategies within their real classroom settings.

Data were generated through three qualitative methods: semi-structured interviews, classroom observations, and document analysis. Interviews enabled the researcher to access teachers' reasoning, reflections, and beliefs about learner errors. Classroom observations provided first-hand evidence of how misconceptions were identified and addressed in practice. Document analysis, which included review and analysis of samples of learners' work and DBE diagnostic reports, offered further insight into the nature and patterns of learner errors. The combination of these methods ensured triangulation, allowing the study to capture both what teachers reported they did and what they actually did when engaging with learners' misconceptions in Measurement. A detailed account of the research paradigm, design, sampling, data generation, and analysis is provided in Chapter 4.

1.10 Significance of the study

This study contributes to both research and practice by deepening understanding of how Mathematical Literacy teachers identify and remediate learners' misconceptions in the topic of Measurement. Its primary significance lies in generating evidence-based insight into the pedagogical decisions teachers make when responding to learner errors, moving beyond generic claims about misconceptions to document concrete strategies used in real classrooms. These findings offer practical guidance for teachers by highlighting instructional approaches, scaffolding techniques, and assessment practices that support conceptual, rather than

procedural, learning in Measurement.

Beyond the classroom, the study has wider relevance for school leadership, curriculum development, teacher education, and policy makers. By showing how systemic factors such as class size, resource availability, language, and time allocation shape teachers' ability to engage with misconceptions, the study provides a basis for school-level support structures and policy interventions that enable effective remediation. Its findings can inform professional development programmes focused on diagnostic pedagogy, as well as curriculum and assessment reforms that prioritise conceptual progression over formula memorisation.

The study therefore makes a three-fold contribution: it strengthens the scholarly literature on misconceptions in Mathematical Literacy, offers practical tools and insights for teachers and teacher educators, and provides evidence that can guide decision-makers in improving the conditions under which Mathematical Literacy is taught. If the recommendations emerging from this research are implemented, the study has the potential to influence learner performance, promote equitable access to mathematical understanding, and support a more concept-driven approach to the teaching of Measurement in South African schools.

1.11 Delimitations of the study

Delimitations refer to the intentional boundaries established by the researcher to define the scope of the study (Theofanidis & Fountouki, 2018). In this study, several delimitations were established in order to allow for an in-depth investigation of learners' misconceptions and teachers' remedial strategies in Mathematical Literacy. First, the study focused specifically on Grade 12 Mathematical Literacy, as this is the final year of schooling in which learners are assessed through the National Senior Certificate examination. Concentrating on Grade 12 allowed the study to examine how misconceptions in Measurement are addressed in a high-stakes assessment context. Second, the study was limited to the topic of Measurement within the Mathematical Literacy curriculum. Measurement was selected because it carries a significant weighting in the Grade 12 examination and frequently appears in national diagnostic reports as an area where learners experience persistent difficulties. In this study, Measurement refers specifically to the concepts addressed within the Space, Shape and Measurement section of the Mathematical Literacy curriculum, including unit conversions, perimeter, area, volume, scale, and time-distance calculations. Other Mathematical Literacy topics such as Finance, Data Handling, and Probability were not included. Third, the study was conducted in one

district in the Free State province, namely the Motheo District. Focusing on a single district enabled the researcher to conduct a detailed examination of classroom practices and teachers' experiences within a specific educational context. Teachers from other districts or provinces were therefore not included in the study. These delimitations were necessary to ensure that the study remained focused and manageable while allowing for a deep exploration of misconceptions and remedial strategies in a clearly defined curricular and geographical context.

1.13 Definitions of key terms

Errors: Errors are mistakes learners make when solving mathematical problems. They can be caused by factors such as misconceptions or a lack of prior knowledge (Derrick et al., 2018).

Misconceptions: Misconceptions refer to erroneous beliefs, misunderstandings, or incomplete understandings of concepts. Misconceptions may arise from cognitive biases, prior experiences, or inadequate instruction (Frick, 2019).

Mathematical Literacy: Mathematical Literacy is a subject in the South African basic education curriculum that focuses on developing practical mathematical skills and competencies for real-life contexts (Bolstad, 2021). It emphasises applying mathematical concepts and reasoning to solve problems and make informed decisions in various domains, including personal finance, civic engagement, and vocational settings (Bolstad, 2021).

Measurement: Measurement encompasses the process of quantifying attributes or properties of objects, events, or phenomena using standardised units (Mari et al., 2023). In this study, Measurement includes concepts such as length, area, volume, mass, time, and temperature, that fall within the Mathematical Literacy curriculum in South African education (DBE, 2016).

Remedial Strategies: Remedial strategies refer to instructional interventions, pedagogical approaches, or teaching techniques designed to address learners' misconceptions and errors in Measurement (Maawa & Cruz, 2019).

1.14 Organisation of the thesis

This thesis is presented in eight chapters, as follows.

Chapter 1: Introduction. The thesis begins with Chapter 1, which introduces and orients the study by outlining the background and context of Mathematical Literacy in South Africa, the

problem of learner misconceptions in Measurement, and the purpose, aims, objectives, and research questions guiding the inquiry. The chapter also presents the research paradigm, approach, and design at a preview level, before explaining the significance, limitations, and key terminology of the study, concluding with a brief outline of the thesis structure itself.

Chapter 2: Literature Review. This chapter provides a thematic and critical review of the existing scholarship on learners' errors and misconceptions in Mathematical Literacy, with a specific focus on Measurement. It begins with an introduction to the literature review process, explains the search strategy, and discusses four dominant areas of misconceptions—procedural, computational, conceptual, and interpretive/application. It then examines the literature on teacher engagement strategies and the factors influencing such engagement.

Chapter 3: Theoretical Framework. This chapter presents the theoretical framework underpinning the study. The chapter introduces constructivism historically and conceptually, outlines its key principles, discusses its strengths and limitations, and justifies its relevance to the study. It further explains how the theory informs the interpretation of learners' misconceptions and teacher responses, linking explicitly to the research questions and providing the theoretical grounding for data analysis.

Chapter 4: Methodology. This chapter details the research methodology, beginning with the interpretivist paradigm and its philosophical assumptions, followed by an explanation of the qualitative case study design, research context, selection of participants, and data-generation methods, which include lesson observations, semi-structured interviews, and document analysis. The chapter explains the procedures for data analysis and approach to ensuring the trustworthiness of the study. Ethical considerations, and limitations of the study are discussed before concluding with a summary of the methodology.

The study's findings are presented in Chapters 5, 6, and 7.

Chapter 5: Findings on learners' common errors and misconceptions in measurement. This chapter presents the findings related to the first research sub-question by identifying learners' common errors and misconceptions in Measurement. The chapter begins with an overview of participant's professional training and experience, then moves into a data-driven thematic presentation of four categories of challenges—procedural, computational, conceptual, and interpretation/application errors—supported by diagnostic reports, learner scripts, and interview data.

Chapter 6: Findings on teachers' engagement with learners' misconceptions and errors in measurement. This chapter responds to the second research sub-question by examining how Mathematical Literacy teachers engage with learners' misconceptions and errors. Drawing primarily from classroom observations, interviews, and learners' workbooks, the findings are presented in seven pre-determined themes: including classroom organisation, lesson introduction, identification of misconceptions, remedial strategies, learner engagement, teaching approaches, and assessment and feedback.

Chapter 7: Findings on teachers' pedagogical reasons for engaging or not with learners' errors and misconceptions. This chapter addresses the third research sub-question by analysing why teachers choose to engage—or not engage—with learners' misconceptions. The chapter uses interview data to develop three major themes: teachers' pedagogical beliefs and motivations, contextual and institutional barriers, and reflective practices informed by feedback. Each theme includes associated sub-themes that explain the underlying reasoning behind teachers' instructional decisions.

Chapter 8: Conclusions and recommendations. This chapter concludes the thesis by synthesising the findings across all three sub-questions, drawing theoretical and practical conclusions, and offering recommendations for teachers, curriculum developers, policymakers, and teacher-education stakeholders. The chapter also outlines the limitations of the study and proposes areas for future research before closing with a final reflection on the study's contribution to Mathematical Literacy teaching and learning.

1.15 Chapter conclusion

Chapter 1 has established the foundation of the study by outlining its purpose, scope, and conceptual orientation. As an introductory chapter, its role is to position the research problem within its educational context, clarify the focus of the inquiry, and signal the theoretical and methodological direction of the study. The next chapter builds on this foundation by presenting a more extensive review of the literature, which situates the study within existing scholarship on learner misconceptions, teacher beliefs, and pedagogical approaches in Mathematical Literacy.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The previous chapter introduced the study, providing a background to the topic of Mathematical Literacy (ML) in South Africa. The problem statement identified the issue of learners' misconceptions and errors in the topic Measurement as a significant challenge in the South African context. The aim of the study to explore the remedial strategies employed by ML teachers to address learners' errors and misconceptions in Measurement was articulated. Research questions were formulated and introduced to explore common learner misconceptions, pedagogical strategies employed by teachers to address learners' errors and misconceptions, and the reasons teachers did or did not engage with learners' errors and misconceptions.

This chapter reviews the literature relevant to this study. A thematic critical literature review involves systematically analysing existing literature to identify and synthesise common themes or patterns across multiple studies on a particular topic. It aims to provide a comprehensive overview of the research landscape, highlighting key findings, trends, and gaps in knowledge (Paul & Criado, 2020).

Understanding how teachers engage with and rectify misconceptions and errors is essential for developing teaching practices that enhance learning outcomes. Thus, the purpose of this chapter is to present a critical and thematic review aimed to provide a comprehensive understanding of the current state of knowledge on this topic and identify areas where further research was needed by highlighting key themes and concepts, providing a solid foundation for future research and practice in this important area of education.

2.2 Systematic review strategy

A systematic and comprehensive strategy was used to ensure the inclusion of relevant and high-quality studies for review. Several well-established academic databases—including university databases, Scopus, Google Scholar, ERIC, and JSTOR—were selected due to their extensive collections of peer-reviewed journals, conference papers, and scholarly articles. The search terms used were carefully selected to capture the breadth of the research topic. They included phrases such as 'Mathematical Literacy', 'Measurement errors', 'teaching strategies', 'remedial strategies', 'learner errors', and 'learner misconceptions'. Combinations of these keywords were employed to refine the search and retrieve the most pertinent literature. For

instance, searches like ‘Mathematical Literacy AND Measurement errors’ and ‘teaching strategies AND Mathematical Literacy’ narrowed the results to the most relevant studies.

Inclusion and exclusion criteria were established to ensure the selection of studies most relevant to the research questions. The scope of the review was confined to recent literature that examines learners’ misconceptions, teaching strategies, remedial interventions related to the Measurement topic of the Mathematics subject. Studies published within the last ten years were prioritised to ensure the inclusion of the most current research findings and practices. The selected literature ranged from empirical research findings to theoretical discussions and practical applications. Only peer-reviewed studies were included to ensure the trustworthiness of the findings. Literature was selected only if it directly addressed one or more of the study’s research sub-questions, focusing specifically on learners’ misconceptions, teaching strategies, and remedial interventions.

Some limitations were encountered in the search for relevant literature. Access to certain journals and articles was restricted, which may have limited the inclusion of potentially relevant studies. Additionally, limited literature was found on the research topic that had been published in the past ten years, reflecting a gap in the literature. These limitations highlight the need for ongoing research and the potential for future studies to build on the findings of this review.

2.3 Errors and misconceptions in Measurement

A ‘learner error’ is generally defined as an incorrect response or action by a learner during the learning process, often resulting from a misunderstanding, misapplication of a rule, or a gap in prerequisite knowledge (Mathaba et al. 2024; Matindike & Makonye, 2023). A ‘misconception’ is a more specific and persistent forms of error, indicating that a learner has an incorrect or incomplete mental model of a concept. A misconception is a part of a learner’s cognitive structure that is not scientifically accurate, which can result in repeated and consistent errors even when instruction is provided (Guerra-Reyes et al., 2024; Majeed et al., 2023; Ili, 2022).

While the broader literature on mathematical misconceptions spans multiple domains of mathematics education, the present study focuses specifically on how these misconceptions manifest in the context of Measurement within Mathematical Literacy. Measurement tasks in Mathematical Literacy often require learners to interpret real-life contexts, apply formulas appropriately, convert units, and reason about spatial relationships such as area, perimeter,

scale, and volume. These tasks therefore integrate several mathematical competencies simultaneously, making them particularly susceptible to different forms of learner errors and misconceptions. Consequently, the categories of misconceptions discussed in the following sections: procedural, computational, conceptual, and interpretation/application errors, are examined with specific attention to how they arise within Measurement tasks in the Mathematical Literacy curriculum.

The four categories of learner errors discussed in this section, procedural, computational, conceptual, and interpretation/application errors, were derived from the existing literature on mathematical misconceptions. These categories provided a conceptual framework for reviewing previous studies and for sensitising the analysis of data in the present study. However, they were not applied as rigid deductive codes during analysis. Instead, they functioned as analytical lenses that informed the interpretation of the data, while allowing additional patterns and themes to emerge inductively during the thematic analysis process described in Chapter 4. In this way, the study combined literature-informed categorisation with inductive thematic development, ensuring that the analysis remained both theoretically grounded and responsive to the empirical data.

2.3.1 Procedural errors and misconceptions in Measurement

Procedural errors in mathematics are mistakes that occur when students do not follow the correct steps or procedures required to solve a problem, even if they understand the underlying concepts (Maulida et al., 2025). In mathematics, procedural misconceptions are mistakes made when using mathematical algorithms or procedures because of poor comprehension of the stages involved (Feldman et al., 2018; Quinoid & Cuarto, 2023).

This section provides an overview of procedural errors and misconceptions that occur during the application of measurement techniques and calculations, and their causes.

2.3.1.1 Procedural errors in Measurement

Procedural errors in mathematics are a common challenge for learners across various levels of education. These errors can manifest as syntactical or algorithmic mistakes and often involve misapplication of mathematical procedures (Maulida et al., 2025). Andriani and Nurhasanah (2021) used Elbrink's theory to identify specific types of procedural errors made by learners at a high school in Sambirejo, Indonesia. The types of procedural errors included misidentification, misgeneralisation, and repair theory. Misidentification occurred when

learners made mistakes applying the algorithm. With misgeneralisation, learners made mistakes when generalising existing concepts. While with repair theory, learners failed to understand and solve mathematical problems (Andriani & Nurhasanah, 2021).

Studies have highlighted procedural errors across mathematical topics like linear programming, improper fractions, quadratic surfaces in vectorial calculus, and integer counting operations (Andriani & Nurhasanah, 2021; Baharuddin et al., 2021). Common procedural errors include inaccuracies when rewriting problems, inefficiencies in calculations, forgetting negative signs, errors in sequence, and incomplete answers. Additionally, errors in mathematical writing, such as incorrect grammar and misuse of symbols, have been identified as prevalent among learners (Guce, 2017). In one study, learners at a primary school in Indonesia frequently make procedural errors when comparing and adding fractions (Lestiana et al., 2016).

2.3.1.2 Procedural Misconceptions in Measurement

Procedural misconceptions can hinder learners' ability to solve mathematical problems accurately. Studies have found procedural errors to be common in the learning of algebra, where learners struggle with correctly applying mathematical procedures (Booth et al., 2017; Ndemo & Ndemo, 2018). A study conducted in the Philippines found that misconceptions related to procedural knowledge, misapplication of formulas, and limited understanding of mathematical concepts were common among senior high school learners learning with a modular modality (Quinio & Cuarto, 2023). Addressing procedural misconceptions is crucial for enhancing learners' mathematical proficiency and ensuring a solid foundation for more advanced mathematical concepts and courses (Booth et al., 2017; Mbonanmbi & Bansilal, 2014).

Research consistently shows that while procedural knowledge (knowing *how* to perform mathematical operations) is essential, an overemphasis on procedures can sometimes overshadow conceptual understanding (knowing *why* those procedures work), leading to misconceptions and errors (Rittle-Johnson & Siegler, 2021). Identifying these errors is challenging because procedural mistakes can take many forms and may mask underlying gaps in conceptual understanding (Tchoshanov & Monarrez, 2024). Studies indicate that students may possess strong procedural skills yet still make errors if their conceptual grasp is weak, and vice versa, highlighting the importance of developing both types of knowledge in tandem (Rittle-Johnson & Siegler, 2021; Tchoshanov & Monarrez, 2024). Hence, automated systems

have been developed to diagnose these misconceptions by analysing learners' answers and inferring incorrect procedures (Feldman et al., 2018). To address these issues, teachers need to understand the nature and source of misconceptions so that they can plan appropriate instruction to address them.

The findings of the studies discussed in this section are context-specific or subject to limitations in generalizability. Thus, the current study aims to build upon this body of work by focusing on the remedial strategies Mathematical Literacy teachers employ to address learner errors and misconceptions in measurement, providing insights directly applicable to South African classrooms.

2.3.1.3 Strengths and weaknesses studies on procedural errors and misconceptions in Measurement

Both strengths and limitations can be identified in the design of previous studies on procedural errors and misconceptions in mathematics, particularly related to the topic of Measurement. Andriani and Nurhasanah (2021) conducted a descriptive qualitative study investigating procedural errors in algebra, employing a systematic framework for analysis based on Elbrink's theory. While their snowball sampling approach facilitated a targeted selection of participants, it potentially introduced bias, limiting the broader applicability of the findings. Similarly, while Baharuddin et al.'s (2021) exploration of errors in integer counting operations among a larger sample of 100 secondary learners in East Indonesia used a validated test and a controlled testing environment to enhance the reliability and validity of findings, the study's focus on a specific age group and region narrowed the generalizability of the findings.

In contrast, Guce (2017) conducted an in-depth, qualitative examination of mathematical writing errors among Mathematics learners, providing detailed insights into learners' procedural skills and conceptual understanding. While the small sample size limited the study's broader applicability, the depth of analysis yielded valuable educational interventions tailored to this specific group. Lestiana et al. (2016) took a similar approach by examining early misconceptions of fraction problems among young learners. The context-specific findings provided a clear understanding of common learner errors that could inform curriculum development for early mathematics education.

The theoretical discussion Booth et al. (2017) present on misconceptions in algebra underscores a different angle. While their study did not contribute new primary data, their literature-backed

analysis presented strategies for enhancing conceptual understanding. The absence of empirical validation limits the generalisation of their recommendations, but the study's theoretical soundness offers foundational insights for further research. Conversely, Ndemo and Ndemo (2018) conducted a cross-sectional survey that combined written tests and interviews to uncover algebraic misconceptions among Zimbabwean learners. This study's systematic sampling method strengthened its reliability; however, its focus on a single school limited broader application.

Feldman et al. (2018) contributed innovatively by developing an automated system to diagnose misconceptions among Mathematics learners in kindergarten through Grade 8. Their large sample size bolstered the reliability of the results, and the high replication rate of known errors indicated the system's effectiveness. However, the system's focus on systematic errors risked overlooking more nuanced misconceptions, and its reliance on predefined algorithms potentially limited its adaptability to unforeseen errors.

Finally, Quinio and Cuarto (2023) took a mixed-methods approach to investigating general mathematics and statistics misconceptions during the COVID-19 pandemic. Their study offered a comprehensive understanding by integrating quantitative surveys with qualitative interviews. Despite the lack of detail on their sample selection process, the study's relevance to contemporary educational challenges was evident, particularly in identifying misconceptions emerging from modular learning environments.

These studies collectively demonstrate that while qualitative and quantitative approaches provide valuable insights into procedural errors and misconceptions, most of the approaches were context-specific or subject to limitations in generalizability. Thus, the current study aims to build upon this body of work by focusing on the remedial strategies Mathematical Literacy teachers employ to address learners' errors and misconceptions in Measurement using a qualitative approach, providing insights directly applicable to South African classrooms.

Most of the literature reviewed suggests that learners' procedural errors and misconceptions are deeply rooted in computational errors and misconceptions. The next section explores the literature on computation errors and misconceptions.

2.3.2 Computational errors and misconceptions in Measurement

Computational errors are mistakes that occur when students incorrectly perform arithmetic or calculation steps, such as adding, subtracting, multiplying, or dividing numbers or symbols

(Mutambara & Bansilal, 2021). These errors are often technical in nature even when the student understands the underlying concept (Mutambara & Bansilal, 2021). Misconceptions, on the other hand, are deeper misunderstandings or incorrect beliefs about mathematical concepts or principles. These are not just mistakes in calculation, but rather errors that stem from flawed or incomplete cognitive structures, such as misunderstanding the meaning of variables, misapplying rules for operations, or holding incorrect ideas about how mathematical processes work (Mathaba et al., 2024; Mutambara & Bansilal, 2021).

This section reviews learners' common computation errors and misconceptions related to measurement, including confusion between units, misunderstanding concepts like area and perimeter, misapplying formulas, basic arithmetic mistakes, incorrect handling of decimals and fractions, misinterpretation of word problems, improper rounding and estimation, and difficulties with spatial awareness and visualisation.

2.3.2.1 Computational Errors in Measurement

Computational errors in measurement often arise from misunderstandings of units, incorrect application of formulas, procedural mistakes, and basic arithmetic errors (Morales Brignac, 2022; Rashid et al., 2021). Learners commonly struggle with unit conversions due to a lack of understanding of unit relationships and poor recall of conversion factors (Morales Brignac, 2022; Rashid et al., 2021; Mbonambi & Bansilal, 2014). Errors applying formulas for area, volume, or perimeter calculations can occur when learners use incorrect formulas or confuse required dimensions (Tastepe & Yanik, 2023). Moreover, basic arithmetic mistakes, such as subtraction, multiplication, or division, can significantly impact the accuracy of measurement calculations (Teketel, 2022). Addressing these issues through targeted educational strategies and emphasising the importance of precision in computations can help learners improve their measurement accuracy and overall mathematical proficiency (Tastepe & Yanik, 2023; Teketel, 2022).

Research indicates that learners struggle to learn measurement concepts; particularly, area and volume (Dorko & Speer, 2015; Tumova & Vondrova, 2017; Machaba, 2016). In a study by Dorko and Speer (2015), 73% of learners gave incorrect units for area and volume tasks, frequently misusing length units. This aligns with findings by Tůmová and Vondrová (2017), who examined secondary school learners in the Czech Republic and found that learners made mistakes in measurement tasks, such as a missing link between an algebraic and geometric representations and had a tendency to linearize and employ pseudo-analytical thinking. The

specific context of the Czech education system limits the generalisability of the findings to other settings. Machaba (2016) found that Grade 10 South African learners taking Pure Mathematics demonstrated confusion about area and perimeter concepts, possibly due to the simultaneous introduction of formulas. Across these studies, learners are reported struggling with unit conversions, misapplication of formulas, and confusion between different measurement concepts. While these studies are not directly focused on Mathematical Literacy, they highlight the importance of reliable measurement practices, providing relevant insights into the challenges of measurement accuracy.

2.3.2.2 Computational Misconceptions in Measurement

As evident in the review of studies in the previous section, misconceptions about measurement often revolve around fundamental concepts such as size, scale, and units, leading to confusing between area and volume (Machaba, 2016; Guerra-Reyes et al., 2024; Majeed et al., 2023; Ili, 2022). Makonye and Fakude (2016) state that misconceptions stem from learners' reliance on rote memorisation rather than a deep understanding of mathematical operations, leading to mistakes when encountering non-routine problems. For example, a common misconception involves incorrectly concluding that doubling the length of one side of a rectangle will double its area when, in fact, the area quadruples (Guerra-Reyes et al., 2024). Such misconceptions may result from a lack of understanding of unit relationships or poor recall of conversion factors, leading to errors (Morales Brignac, 2022; Rashid et al., 2021).

Tan Sisman and Aksu (2016) found that learners had misconceptions about spatial measurement, such as believing all rulers were 30 cm long and confusing the area formula with the perimeter formula. Additionally, Majeed et al. (2023) found that learners frequently confused perimeter and area, using the terms interchangeably despite their distinct mathematical properties. Smith et al. (2016) identified five main computational misconceptions learners held regarding measurement: conserving area as a quantity, understanding area units, structuring rectangular space, comprehending area formulas, and distinguishing area from perimeter. Furthermore, Smith et al. (2016) found that such errors emanate from instructional practices, which often present area measurement in procedural terms, with limited emphasis on conceptual understanding, particularly regarding how the multiplication of lengths produces area measures.

The above findings show that computation errors and measurement misconceptions present significant learning barriers. These misconceptions persist due to various factors, including the

simultaneous introduction of formulas for the concepts of area and volume, which both involve measurements (Machaba, 2016). Thus, addressing these misconceptions requires targeted teaching strategies and interventions to enhance conceptual understanding and promote accurate knowledge acquisition in educational settings (Islamiyah et al., 2022).

Research indicates that by prioritising conceptual understanding, employing diagnostic assessments, and utilising interactive teaching methods, teachers can help learners overcome these challenges and achieve greater mathematical proficiency (Jamaludin & Maat, 2020; Machaba, 2016; Bansilal & Debba, 2012).

A review of literature conducted by Jamaludin and Maat (2020) found that most studies on learners' misconceptions of mathematics have focused on primary school learners. The study found that most of the studies conducted were aimed at determining misconceptions rather than overcoming students' misconceptions in mathematics education (Jamaludin & Maat, 2020). To address this gap, this study explores the phenomenon in secondary schools by exploring instructional strategies to address learners' errors.

2.3.3 Conceptual errors and misconceptions in Measurement

Conceptual errors are mistakes that arise from a misunderstanding or incomplete understanding of mathematical concepts, principles, or relationships. These errors occur when students do not grasp the underlying ideas behind mathematical operations or topics, leading to incorrect reasoning, misinterpretation of problems, or the application of wrong concepts to solve problems (Sanina & Sokolov, 2021). These errors stem from misconceptions of fundamental mathematical concepts and can persist as learners progress, leading to incorrect reasoning and inability to solve problems (Kurudirek et al., 2025; Sanina & Sokolov, 2021). Conceptual misconceptions are misunderstandings or incorrect beliefs about fundamental mathematical concepts that hinder learners' ability to develop deep conceptual understanding and solve problems accurately. These misconceptions often arise when students build inaccurate or incomplete mental models of mathematical ideas, which can be influenced by factors such as cognitive styles, learning methods, prior experiences, and teachers' instructional approaches (Kurudirek et al., 2025; Fardah & Palupi, 2023; Weliwita et al., 2020).

This section reviews conceptual errors and misconceptions in measurement where learners have fundamental misunderstandings or incorrect beliefs about measurement principles, such

as confusing different types of measurement (e.g., area versus perimeter or volume versus surface area), misinterpreting units, and applying measurement concepts incorrectly.

2.3.3.1 Conceptual errors in Measurement

Research has identified different types of errors, such as factual, procedural, and conceptual, with conceptual errors mainly being problematic (Sanina & Sokolov, 2021; Roell et al., 2019). These conceptual errors are seen across various mathematical topics, such as in arithmetic operations with negative numbers, fractions, and algebraic concepts involving variables, functions, and graphs (Hasibuan et al., 2022; Yasseen et al., 2020).

Learners often make conceptual errors due to a lack of understanding of the question, carelessness in calculations, inability to convert problems into mathematical models, and insufficient knowledge of problem-solving steps (Hasibuan et al., 2022). Detecting and addressing these errors is crucial as this can significantly impact learners' performance and achievement in mathematics (Yasseen et al., 2020). If left undetected, these errors can hinder their ability to comprehend new concepts and apply mathematical principles accurately (Yasseen et al., 2020). Identifying conceptual errors early and providing targeted interventions and instructional strategies can help learners better understand mathematical concepts and improve their problem-solving skills.

2.3.3.2 Conceptual misconceptions in Measurement

Studies have identified conceptual misconceptions of definitions, classifications, correlations, strategies, signs, and systematic errors among learners (Abakah & Brijlall, 2024; Fardah & Palupi, 2023). These misconceptions can manifest at different levels of mathematical ability, with learners of varying abilities experiencing challenges understanding concepts like quadrilaterals and linear systems (Sari & Masriyah, 2022). These misconceptions are prevalent in algebra, fractions, and decimal operations (Weliwita et al., 2020). Additionally, Fuat et al. (2020) found that misconceptions stemmed from learners' preconceptions, abilities, textbooks, and teaching methods. Fuat et al. (2020) also found two main types of misconceptions which are (1) classificational execution misconceptions and (2) theoretical execution misconceptions, particularly in plane geometry (Fuat et al., 2020).

In contract to the study by Fuat et al. (2020), which focused on learners' misconceptions, a study conducted by Kusmaryono et al. (2020) that focused on elementary school teachers in Indonesia found that teachers harboured misconceptions in teaching mathematics

(Kusmaryono et al., 2020). The results demonstrate teachers equally experienced the following types of misconceptions: preconception, under-generalization, over-generalization, modelling errors, prototyping errors, and process-object errors. Due to teachers' long-held conviction that the information they were taught was accurate. Some of ontological misconceptions had become entrenched and were challenging to eradicate (Kusmaryono et al., 2020). As such addressing conceptual misconceptions is crucial to promoting a solid foundation of mathematical understanding among learners.

2.3.3.3 Strengths and weaknesses of studies on conceptual errors and misconceptions in Measurement

This section critiques the methodology used in previous studies conducted on conceptual errors and misconceptions in Measurement.

2.3.3.3.1 Strengths and weaknesses of studies on conceptual errors in Measurement

A plethora of studies have been conducted outlining different types of conceptual errors and identifying misconceptions that underlie them. While each study provides valuable insights, this section critiques their methodologies to identify gaps that could be addressed in the present study.

Mbonambi and Bansilal (2014) contribute valuable insights into the differences in algebraic proficiency of Mathematics and Mathematical Literacy learners, especially regarding their ability to solve temperature conversion problems. The strengths of their study include a solid comparative approach, real-world relevance, and practical recommendations for improving algebraic skills. However, the study is limited by its narrow focus on one topic, the restricted geographical scope of the sample, and its lack of analysis of instructional and curricular factors. A broader exploration of algebraic proficiency across different topics and cognitive factors and a more diverse sample would enhance the study's applicability and usefulness to a wider educational context.

A systematic literature review by Guerra-Reyes et al. (2024) applies the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines, ensuring methodological rigour in identifying a broad range of learner errors across natural sciences. Although their findings are comprehensive, the broad focus on the sciences means the direct application of these insights to ML is limited. Majeed et al. (2023) offer a more focused approach, using semi-structured interviews to explore learners misconceptions in Chemistry.

The depth of qualitative insights yielded by this study compensates for the small sample size, but the study's reliability is somewhat compromised by potential interviewer bias.

Turning specifically to Mathematics, Ili (2022) conducted an in-depth analysis of three fourth-grade learners' misconceptions of quadrilaterals. The extremely small sample size in this study limits the broader applicability of its findings. Makonye and Fakude (2016) conducted a more robust study, examining errors in directed number operations among Grade 8 learners using a combination of analysis of learners' responses and interviews. To analyse the findings, they used content analysis grounded in Schoenfeld and Kilpatrick's (2008) strands of mathematical proficiency. Their study not only identified specific misconceptions but also provided a clearer understanding of learners' difficulties in Mathematical Literacy than smaller, more isolated studies.

Using pedagogical tools such as flashcards, Rashid et al. (2021) examined unit conversion, revealing interesting insights into learners' perceptions. However, as with many perception-based studies, subjective biases may have clouded the findings, despite the objective quantitative data obtained from pre-test and post-test results. Similarly, a large-scale study by Tan Sisman and Aksu (2016) on spatial measurement misconceptions of Grade 6 learners offers a more reliable dataset, supported by rigorous task design and comprehensive analysis methods, making it a cornerstone for understanding learners' errors in Measurement.

Other scholars have used more theoretical approaches. For instance, Sanina and Sokolov (2021) reviewed mathematical errors using a typology that distinguishes between factual, procedural, and conceptual errors. Their systematic review categorised misconceptions in a way that can guide teachers in addressing these issues. However, their reliance on secondary sources may have failed to account for more recent empirical developments. Roell et al. (2019), in contrast, provide robust empirical evidence of the role of inhibitory control in overcoming whole-number bias in decimal comparisons, contributing to a developmental understanding of learners' mathematical reasoning.

Studies by Hasibuan et al. (2022) and Napfiah and Sulistyorini (2021) further enrich this discourse by exploring the nature of errors through descriptive qualitative methods. These studies highlight learners' conceptual challenges; however, the small sample sizes limit their generalizability. Conceptual papers such as Yasseen et al. (2020) also play a critical role in

framing the discussion around misconceptions—particularly, in algebra—offering theoretical insights without primary empirical data.

While these studies significantly advance our understanding of errors and misconceptions, most focus primarily on learners' experiences, often neglecting teachers' strategies to address these issues. The current study seeks to address this gap by shifting the focus from identifying errors to exploring the remedial strategies that ML teachers use to engage and rectify learners' misconceptions—especially in measurement. By integrating the insights gained from previous research into the practical realm of teaching strategies, this study aims to fill a crucial gap in the literature, bridging the divide between theory and practice.

2.3.3.3.2 Strengths and weaknesses of studies on conceptual misconceptions in Measurement

The literature on conceptual misconceptions in mathematics, particularly in Measurement, reveals various insights into the nature and causes of learners' misunderstandings across different contexts and mathematical areas. For example, Abakah and Brijlall's (2024) qualitative case study in South Africa uses the Structure of the Observed Learning Outcomes (SOLO) theory to systematically analyse learners' algebraic misconceptions, offering a robust method for identifying misconceptions through a combination of classroom observations, activities, and interviews. While this study ensures reliability through data triangulation, its focus on a single context limits its generalizability. Sari et al. (2024) examined scaffolding techniques to address mathematical problem-solving by learners with anxiety about mathematics. The use of multiple instruments, including problem-solving ability tests and anxiety questionnaires, adds depth to the qualitative insights derived in this study; however, the small sample size again limits the generalizability of findings.

Large-scale studies like that of Weliwita et al. (2020), which examined misconceptions among 132 engineering students, offer more empirical rigour through conceptual error tests and confidence questionnaires. The large sample size and statistical analysis enhance the reliability and validity of the results, although the focus on engineering students limits the findings' transferability to other disciplines. Fuat et al. (2020) provides a detailed classification of misconceptions in plane geometry, using a descriptive qualitative approach that supports validity through comprehensive analysis but is restricted by its focus on a specific mathematical domain.

In a study focusing on teachers' knowledge, Fardah and Palupi (2023) explored misconceptions about linear equations in two and three variables among 29 prospective mathematics teachers. Their use of diagnostic tests provided direct evidence of conceptual errors, strengthening the validity of the findings, but the small sample size constrained the study's broader applicability. Kusmaryono et al. (2020) identified misconceptions among 30 elementary schoolteachers in Indonesia, enhancing the study's reliability by triangulating teachers' responses. However, as with many qualitative studies, its context-specific findings may not extend beyond the educational setting in which the study was conducted.

These studies underscore the prevalence of learners' misconceptions across various mathematical areas and the importance of qualitative and quantitative approaches in addressing them. However, a common limitation in many of these studies is the context-specific or discipline-focused nature, which often restricts the broader application of their findings. The current study aims to build on this body of work by focusing on the remedial strategies ML teachers employ to address learners' errors and misconceptions in measurement, thus generating context-specific insights that can directly inform teaching practices in South African classrooms.

Although many of the studies reviewed in this section originate from broader mathematics education contexts, the insights they provide are directly relevant to Measurement tasks in Mathematical Literacy, where learners are frequently required to perform unit conversions, interpret spatial relationships, and apply formulas within real-life contexts.

2.3.4 Interpretation and application errors and misconceptions in Measurement

Interpretation errors and application errors are discussed together in this section because, in the context of Mathematical Literacy Measurement tasks, these two types of errors often occur simultaneously. Measurement problems typically involve interpreting contextual information from word problems, diagrams, or scale drawings before applying appropriate mathematical procedures. As a result, difficulties in interpreting the problem context frequently lead directly to incorrect application of formulas or procedures. For this reason, interpretation and application errors are treated as intertwined processes rather than entirely separate categories of misconceptions in this study.

Interpretation errors often involve misreading or misunderstanding mathematical statements, symbols, or problem contexts, such as confusing the meaning of variables, misinterpreting the

equal sign, or incorrectly translating word problems into mathematical expressions (Wilujeng & Alvarez, 2025; Khalid et al., 2020; Owusu et al., 2023). Application errors refer to mistakes in applying mathematical procedures or concepts, including procedural missteps (like incorrect arithmetic or symbol manipulation), misuse of mathematical rules, or failure to apply concepts appropriately in new situations (Mathaba et al., 2024; Owusu et al., 2023).

Misconceptions are persistent, incorrect beliefs or mental models about mathematical concepts, such as thinking that a letter always represents the number 1 in algebra or misunderstanding the properties of operations with integers and fractions (Wilujeng & Alvarez, 2025; Kurudirek et al., 2025; Khalid et al., 2020; Owusu et al., 2023). These misconceptions can stem from over-reliance on rote procedures, lack of conceptual understanding, language deficiencies, or ineffective teaching strategies (Kurudirek et al., 2025; Al-Rababaha et al., 2020; Owusu et al., 2023). Research shows that students often hold these misconceptions with high confidence, making them resistant to change without targeted instructional interventions, such as diagnostic assessments, conceptual change strategies, and explicit feedback (Wilujeng & Alvarez, 2025; Kurudirek et al., 2025; Prakash et al., 2021). Addressing both interpretation and application errors, as well as underlying misconceptions, is crucial for improving mathematical proficiency and fostering deeper understanding (Kurudirek et al., 2025; Prakash et al., 2021).

Research has identified various interpretation and application errors made by learners in mathematics. For example, errors may occur during data extraction, statistical analyses, and interpretation, with many related to model selection and heterogeneity assessment (Kanukula et al., 2024). Learners have been found to struggle with symbol sense, resulting in errors in the representation of variables, numbers, and relational operators (Wardah et al., 2021; Bansilal & Debba, 2012). When interpreting figures, common mistakes by learners include omission, syntactic, and lexical errors, especially with large integers, fractions, and percentages (Huang et al., 2020). In modelling tasks, pre-service mathematics teachers have demonstrated higher error frequencies in phases involving real situations, such as simplification and validation (Verdejo et al., 2021). These findings highlight the importance of addressing interpretation and application errors in mathematics education and research to improve accuracy and understanding across various mathematical areas.

A study by Khalid et al. (2020) found that Grade 7 learners in Brunei exhibited several misconceptions when interpreting letters and symbols in routine algebraic problems. These included combining numbers during addition (treating letters as if they could be added directly

to numbers), equating a letter with 1 (assuming any letter in an algebraic expression always represents the number 1), and a misconception of the equal sign (viewing the equal sign as simply associating with the value or letter closest to it, rather than as a symbol of equivalence) (Khalid et al., 2020). Additional errors identified were inconsistency with self-made rules (students inventing and inconsistently applying their own rules) and understanding letters to be abbreviations for names of objects, rather than representing variables (Khalid et al., 2020).

These misinterpretations extend to solving mathematics word problems, where students struggled with inconsistency in interpreting problem sentences, misuse of mathematical symbols, and difficulties with arithmetic procedures, especially with fractions and their operations (Khalid et al., 2020). Pulungan (2019) also found that a lack of understanding of the problem, formula concepts, and checking answers resulted in errors. Thus, teachers need to diagnose the source of the error so that they can devise appropriate strategies to remedy it.

2.4 Teachers' engagement with errors and misconceptions in Measurement

This section reviews the literature on teachers' engagement with learners' errors and misconceptions in Measurement, focusing on strategies used by teachers to engage with learner's errors and misconceptions and factors influencing teachers' engagement. The strengths and weaknesses of the studies conducted on these topics is reviewed.

2.4.1 Strategies used by teachers to engage with learners' misconceptions and errors in Measurement

This section reviews the strategies used by teachers to engage with learners' misconceptions and errors in Measurement that are reported in the literature.

2.4.1.1 Diagnostic assessment

Teachers use diagnostic assessment to identify learners' specific misconceptions and errors. These assessments may include pre-tests, quizzes, and informal assessments conducted during lessons. According to Li et al. (2020), cognitive tests are reliable for assessing kindergarteners' mathematics problem-solving in the number and operations domains. In South Africa, national diagnostic assessments for strategic calculation in Grade 3 show potential for promoting efficient teaching and improving learner fluency in key calculation strategies, as discussed by Graven and Venkat (2021). Their study on piloting national diagnostic assessments demonstrates the value of these tools in enhancing educational outcomes.

However, the effectiveness of diagnostic assessments can vary based on teachers' understanding and implementation. Mjenda et al. (2023) found that secondary mathematics teachers in Tanzania often misunderstood the role of diagnostic assessments and did not use them efficiently. This highlights the need for professional development to improve teaching and learning practices. Emphasising the importance of well-designed diagnostic assessments, Ketterlin-Geller et al. (2019) suggest using cognitive learning theories to design these tools. Such an approach helps teachers identify misconceptions and errors, aiding instructional decision-making.

2.4.1.2 Error analysis

Error analysis in mathematics education involves identifying, interpreting, and using learners' mistakes to improve understanding, engagement, and learning outcomes by diagnosing strengths and weaknesses and providing targeted instruction (Suciati & Sartika, 2023; Glovňová, 2020; Rushton, 2018). Analysing errors made by learners helps teachers understand the root causes of misconceptions. This involves analysing the steps by which learners arrive at their answers and identifying where they went wrong. However, Long et al. (2014) found that this can prove difficult, especially when they found that indiscriminate mark allocations exist, which contravened assessment and measurement principles.

Error analysis in mathematics education also involves identifying factors influencing learners' mistakes, such as personal characteristics, mathematical abilities, and gender, which helps to identify learners' strengths and weaknesses. Suciati and Sartika (2023) emphasise that understanding these diverse characteristics is crucial for effective error analysis, aiding in developing targeted instructional strategies.

Mathematics error-analysis activities significantly enhance classroom interaction, boosting learners' engagement and improving learning outcomes. Moreover, viewing errors as opportunities for learning is a key aspect of error analysis in mathematics. Glovňová (2020) argues that focusing on errors helps learners understand mathematical concepts more deeply and efficiently. This approach has been shown to enhance learners' proportional reasoning abilities significantly. Error analysis also involves reviewing learners' answers to identify common patterns of misunderstanding, such as comprehension errors, transformation errors, process skills errors, and encoding errors, as highlighted by Rushton (2018). This detailed analysis helps pinpoint specific areas where learners struggle.

2.4.1.3 Addressing misconceptions directly

Addressing misconceptions directly in mathematics education involves designing lessons that capitalise on errors as learning opportunities. Ridho and Juandi (2023) highlight the importance of recognising learners' misconceptions to provide targeted instructional interventions. To achieve this, La Hadi and Dedyerianto (2020) emphasise the importance of creating an environment where learners feel comfortable discussing their mistakes with peers and the teacher. This approach not only helps in identifying and correcting misconceptions but also encourages active engagement and collaborative learning.

Caniglia (2020) supports this view, suggesting that promoting self-reflection over re-teaching can lead to learners developing better conceptual understanding and improved problem-solving skills. 'My Favourite No' technique is a pedagogic strategy designed to address students' misconceptions and promote deeper conceptual understanding. In this approach, a teacher selects a student's incorrect answer—referred to as their 'favourite no'—and uses it as a learning opportunity for the whole class (Caniglia, 2020). The class analyses the mistake together, discussing what was done correctly and where the error occurred, which encourages self-reflection and helps students see the value in making and learning from mistakes (Caniglia, 2020)

However, Bansilal and Mkhwanazi (2014) found that teachers—especially novice teachers—still needed help understanding some of the concepts in Mathematical Literacy, making it difficult for them to address learners' misconceptions directly because they lacked the necessary skills.

2.4.1.4 Scaffolding

Scaffolding involves teachers or peers assisting learners with tasks beyond their current abilities and gradually reducing the support as they become more capable (Retnodari et al., 2020). This technique can be applied across various educational levels, from early primary education to tertiary education (Bawadi et al., 2023). In inclusive classrooms, scaffolding is tailored to the specific needs of learners with special needs (Jannah et al., 2019). The process typically involves three levels: environmental provisions, explaining and reviewing, and developing conceptual thinking (Jannah et al., 2019; Arifin et al., 2020). Studies report that scaffolding techniques can effectively improve learners' understanding of mathematical

concepts (Bawadi et al., 2023) and support reflective thinking skills development in mathematics and statistics courses (Arifin et al., 2020).

Scaffolding is an essential technique that teachers use to support learners as they work through measurement problems. This support can take various forms, such as providing step-by-step instructions, guided practice, and hints or prompts to help learners think through problems (Arifin et al., 2020; Widjajanti et al., 2019). Scaffolding aims to enhance learners' understanding and problem-solving skills in mathematics by offering different levels of support based on the learners' abilities. Low-ability learners receive immediate support, moderate-ability learners receive partly delayed support, and high-ability learners receive delayed support (Khan et al., 2022; Alharbi & Shet, 2023; Tay & Toh, 2023; Bawadi et al., 2023; Widjajanti et al., 2019).

Various studies highlight the effectiveness of scaffolding in different mathematical contexts. The Devising a Plan (DP) model proposed by Toh and Toh (2023) focuses on teachers scaffolding learners to create a plan for mathematical problem-solving, incorporating metacognitive strategies and problem-solving heuristics. Wedastuti et al. (2022) found that scaffolding improves learners' mathematical thinking skills in social arithmetic, facilitating their progression through problem-solving stages. Additionally, Sari et al. (2024) show that scaffolding helps learners with mathematics anxiety improve their problem-solving abilities by supporting explanation, review, and restructuring.

2.4.1.5 Multiple representations

Multiple representations in mathematics involves using more than one mode to present mathematical concepts; this may include verbal, graphic, algebraic, and numeric modes (Mainali, 2021; Zhang et al., 2024; Jitendra et al., 2022). Bicer (2021) argues that this approach enhances teaching and learning by promoting deeper understanding and fostering mathematical creativity. Various studies indicate that using multiple representations in mathematics enhances conceptual knowledge, problem-solving, estimation accuracy, understanding of mathematical structures, and teaching effectiveness and is influenced by cultural and professional factors (Jitendra et al., 2022; Mainali, 2021). Concrete and semi-concrete representations, concurrent presentation of different representations, and mathematical discourse are effective strategies for supporting learners' understanding (Jitendra et al., 2022). Also advocating for using multiple representations, Mainali (2021) posits that developing the ability to translate between different representation modes is crucial for mathematical proficiency. This means that

incorporating multiple representations in mathematics education can improve learners' comprehension, creativity, and problem-solving skills across various age groups and abilities.

By incorporating multiple representations, teachers can support learners in transitioning from informal to formal levels of understanding, facilitating the development of flexible knowledge and the ability to interpret, coordinate, and translate across different representations (Zhang et al., 2024; Jitendra et al., 2022). Furthermore, utilising multiple representations concurrently within lessons and encouraging mathematical discourse can aid in fostering a deep understanding of underlying mathematical structures and improving learners' mathematical competence and communication skills (Zhang et al., 2024; Jitendra et al., 2022).

2.4.1.6 Peer collaboration

Encouraging learners to work in pairs or groups allows them to discuss their thinking and reasoning with peers. This can help learners identify and correct misconceptions through discussion and explanation. Peer collaboration in mathematics education encompasses various approaches and outcomes, integrating disciplinary skills, decision-making skills, knowledge strengthening, and social interaction (Pepkolaj et al. (2020; Campbell, 2021).

Pepkolaj et al. (2020) highlight the benefits and potential drawbacks of collaborative learning in high school mathematics. They found that while it enhanced social interaction and knowledge acquisition, it led to issues such as group assessment challenges and time inefficiency. Johnston (2020) found that having students act as peer-leaders in undergraduate mathematics courses increased the understanding of the content and contributes significantly to the learning and teaching process.

Walker et al. (2021) focused on peer-led group learning, where small groups regularly meet with a peer with additional expertise in the subject matter to work on problems collaboratively. This method fosters a deeper understanding of mathematical concepts through collective problem-solving. Walker et al. (2021) found that collaborative learning promotes the development of knowledge and skills through interdependent, epistemological, and subject-specific approaches. Moreover, peer collaboration in mathematics involves learners sharing social and intellectual authority. Langer-Osuna et al. (2020) observed that while the distribution social authority is more dynamic, intellectual authority tends to remain stable during collaborative activities. This dynamic interplay enhances the learning experience, fostering a deeper engagement with mathematical concepts.

A form of peer collaboration, peer tutoring is described by Hidayat et al. (2023) as a learner-centred teaching method where learners learn in pairs under teacher supervision. This approach improves mathematical achievement and enhances social and cognitive skills. Tachie (2022) found that peer collaboration helps teachers identify threshold concepts and effectively teach foundational mathematics, making it a valuable strategy at the elementary level. Contrasting these collaborative approaches, Campbell (2021) examined the shift from traditional teaching and learning methods to peer-to-peer collaboration in mathematics. This shift emphasises learner discourse and interaction, promoting a more engaging and effective learning environment.

2.4.1.7 Formative assessment and feedback

Formative feedback in mathematics is a pedagogical approach crucial to enhancing learning outcomes by providing timely and supportive feedback to learners during the learning process (Niyibizi & Mutarutinya, 2024). Providing timely and specific feedback on learners' work helps them understand and learn from their errors. The primary aim of formative assessment in mathematics is to gather and analyse information on learner progress in real-time, allowing teachers to identify areas where learners are struggling and make necessary instructional adjustments (Moreno & Pineda, 2020). This real-time adjustment is facilitated by the quality of teacher feedback and scaffolding, which positively predict learners' use of feedback, ultimately improving their mathematics performance (Kyaruzi et al., 2019). Feedback should focus on the process as well as the final answer (Niyibizi & Mutarutinya, 2024).

Studies have shown that implementing innovative assessment methods like formative assessments, project-based learning, and timely feedback significantly improves learners' comprehension, engagement, and overall performance in mathematics education (Niyibizi & Mutarutinya, 2024; Bansilal & Debba, 2012). Furthermore, generative AI-based formative feedback has been found to boost mathematics learners' motivation by increasing confidence, promoting socio-emotional interaction, and stimulating interest and effort in learning (Zheng & Tse, 2023). Feedback mechanisms in formative assessment processes enhance communication and problem-solving strategies and improve learners' awareness of mathematical concepts and their work, ultimately leading to better learning outcomes in mathematics education (Fiorentino & Montone, 2023). Rakoczy et al. (2018) highlighted that learners perceive formative feedback as particularly useful, which increases their self-efficacy, engagement and performance in the subject. Similarly, Kyaruzi et al. (2019) emphasise that

mathematics teachers' positive perceptions of formative assessment (FA) and assessment for learning (AfL) predict the quality of their feedback practices, which in turn enhances learner outcomes.

However, formative feedback often focuses on the process rather than simply providing solutions, which can sometimes pose challenges to learners. Green (2021) found that primary school learners may struggle with understanding social and socio-mathematical norms when receiving formative feedback. On the other hand, Enu and Ngcobo (2022) found that mathematics teacher teachers in Ghana often concentrated on providing corrective measures, rather than helping learners regulate their learning with more learner-centred feedback practices such as formative feedback.

Interactive feedback (IF) represents another effective approach in formative assessment. Barana et al. (2021) describe interactive feedback as a step-by-step interactive process that guides learners in resolving tasks after their initial attempts. This method not only helps to improve their results but also promotes a deeper understanding of mathematical concepts.

2.4.1.8 Real-world applications

Integrating measurement concepts with real-world applications significantly enhances learners' engagement and understanding by demonstrating the relevance and practicality of their studies. This approach can motivate learners to engage more deeply with the material and reduce misconceptions (Aziza, 2024; Al-Mutawah et al., 2021). Research indicates that incorporating real-life examples into subjects like mathematics increases learners' engagement and comprehension (Bennet & Sjögren, 2018; Bansilal, 2014). Additionally, active learning exercises and client-focused projects effectively enable learners to develop applied skills and prepare for future roles (Maddox et al., 2018). This integration enriches educational experiences and equips learners with valuable skills for future endeavours.

Incorporating real-life applications into educational curricula makes learning more engaging, practical, and relevant (Aziza, 2024). Using realia, or real-life objects, creates immersive learning experiences that captivate learners' interest and deepen their understanding (Aziza, 2024). This approach promotes multi-sensory engagement and cultural understanding. Introducing real-world projects into the curriculum also helps learners develop practical project management competencies and applied skills, enhancing their future career prospects (Maddox et al., 2018; Bansilal, 2014). Ultimately, demonstrating the usefulness of mathematics in real-

world applications enhances learners' learning experiences and motivation to engage with the subject (Al-Mutawah et al., 2021).

Bansilal et al. (2012) indicated that teachers required a range of skills use real-world applications effectively that required flexibility in participation for success in contextual domains. Pillay and Bansilal (2018) discovered that teachers' explanations of contextual terms were occasionally inaccurate and irrelevant to learners because they failed to provide guidance on how to interact more deeply with the contextual tools in a way that would increase their level of participation.

2.4.1.9 Reflective practice

Reflective practice in mathematics education is recognized as essential for both teacher development and improved student learning outcomes. Research shows that when mathematics teachers engage in ongoing reflection—through self-assessment, collaboration with peers, and seeking student feedback—they are better able to select and adapt instructional strategies that address misconceptions and meet diverse learner needs (Altaani, 2024; Aghakhani et al., 2023). Reflective practices promote continuous professional growth, help teachers align their attitudes and methods with current educational demands, and support the creation of positive classroom environments (Aghakhani et al., 2023). Integrating reflective pedagogy with technology and providing structured opportunities for reflection—such as guided journals, peer discussions, and video analysis—can enhance teachers' ability to contextualize their content knowledge and improve instructional effectiveness (Tobondo, 2025).

However, studies also reveal that the quality and depth of reflective practice can vary, with some teachers and student teachers primarily engaging in surface-level reflection rather than deeper analysis and adaptation of their teaching (Ngololo & Kanandjebo, 2021). While Aldahmash et al. (2021) found that in-service mathematics teachers exhibited intermediate to advanced reflective thinking skills, particularly in their self-assessing abilities, Ngololo and Kanandjebo (2021) found that pre-service teachers often have insufficient reflective skills, limited to technical reflection and reflection-in-and-on-action, which indicates a need for more structured reflection training. This is supported by Tatira (2023) who also found that pre-service teachers operated at the practical reflection level, with few reaching the critical reflection stage. Thus, joint reflection by pre-service teachers and supervisors or researchers enhances teaching practices and the effective use of technology in the classroom (Nel, 2021). Additionally, using

tools like Google Classroom, discussion forums, and text messaging effectively supports reflective learning by encouraging collaboration and experiential learning (Nel, 2021).

These strategies emphasise the importance of understanding and addressing errors within a supportive learning environment, enabling misconceptions to be used as opportunities for growth. By implementing these methods, teachers can enhance learners' understanding, motivation, and engagement in mathematics.

While all the strategies discussed in this section offer valuable approaches to enhancing the teaching and learning of Mathematical Literacy, the strategies that are grounded in a constructivist understanding of teaching and learning are particularly relevant to this study. Emphasising learner engagement and active, real-world application aligns closely with the goals of Mathematical Literacy, which seeks to blend classroom learning with practical life skills. Constructivist strategies not only encourage learners to actively confront and correct misconceptions but also support deeper understanding by connecting abstract concepts to learners' experiences, promoting a learning environment that addresses misconceptions in a meaningful and lasting way.

2.4.1.10 Strengths and weaknesses of studies conducted on teacher engagement strategies in Measurement

The studies reviewed in this section offer critical insights, while their particular limitations highlight areas for further research. For instance, the study by Bansilal and Mkhwanazi (2014) contributes to understanding how Mathematical Literacy teachers engage with contextualized rules like income tax calculations. Its strengths lie in its contextual relevance—as it was conducted in South Africa, diverse data collection methods, and practical implications for curriculum development. However, its limitations—which include a e being set within a classroom setting, small sample size, and lack of exploration into learners' experiences—call for further research to confirm and extend its findings. By addressing these weaknesses, future studies could provide a more comprehensive understanding of how contextual rules are taught and learned in both classroom and real-life settings.

A study by Long et al. (2014) conducted in the same year contributes valuable insights into the scoring of ML assessments, focusing on improving the coherence and fairness of test items using Rasch measurement theory. Its strengths lie in its rigorous methodological approach, the attention to detail in its scoring logic, and its relevance to ML teachers. However, limitations

such as the small sample size, limited generalizability, and the complexity of the statistical techniques for everyday teachers must be considered. Future research could expand on these findings by including larger, more diverse samples, incorporating learner perspectives, and providing more practical recommendations for both assessment and instruction.

To close the gap of the limitations between a classroom setting and a small sample size, such as in the study by Bansilal and Mkhwanazi (2014), Li et al. (2020) developed a cognitive diagnostic test to assess kindergarteners' mathematics problem-solving skills. While the large sample size of 747 children enhanced the reliability of the test's psychometric properties, the focus on a single educational level (kindergarten) limits the broader applicability of the results. The study's emphasis on early education provides a foundation for understanding young learners' cognitive skills. Still, the instrument developed by these researchers requires further validation in diverse educational contexts to confirm its broader utility across age groups.

Graven and Venkat's (2021) pilot of national diagnostic assessments in South Africa sought to improve strategic calculation skills by shifting focus to Grade 3 learners. The use of pre- and post-assessments and collaboration with mathematics education specialists strengthened the intervention's instructional relevance. Although the study concentrated on the specific strategy of bridging through ten, which may limit generalizability, the findings suggest potential applications to other mathematical literacy areas—such as Measurement, the focus of the current study.

Extending the exploration of diagnostic assessments, Mjenda et al. (2023) examined secondary mathematics teachers' understanding of these assessments through in-depth interviews. Their phenomenographic approach offered rich qualitative insights into teachers' conceptualizations, yet the small, geographically limited sample reduced the generalizability of the results. Nonetheless, this study's exploration of teachers' perspectives provides an important lens through which to view the practical implementation of diagnostic tools in the classroom, echoing the need for more extensive research in diverse contexts.

Ketterlin-Geller et al. (2019) propose that integrating cognitive theories into diagnostic assessment design offers a more theoretical perspective, focusing on content sequencing and diagnostically relevant distractors. While their framework is robust, its application is limited to middle-school mathematics in the United State, and empirical validation is necessary to confirm the effectiveness of these design considerations. This theoretical underpinning lays a

foundation for developing more refined diagnostic assessments across different educational levels and subjects, including ML.

Systematic reviews such as that conducted by Suciati and Sartika (2023) provide an analytical overview of learners' errors in mathematics. While Suciati and Sartika (2023) employed the PRISMA model to ensure methodological rigour, the review's reliance on secondary data results in variable quality and methodological approaches across the studies, which could affect the overall validity of the findings. While the review covers a broad range of theoretical perspectives, its breadth may come at the expense of a deeper analysis of each perspective. Despite these limitations, such reviews offer a comprehensive backdrop against which to situate individual studies.

Error analysis and scaffolding are closely linked to diagnostic assessment practices, as demonstrated by Rushton (2018), who employed a mixed-method design to investigate error analysis in Grade 7 mathematics. This approach allowed for quantitative and qualitative data triangulation, providing statistical significance and deeper insights into participants' experiences. In addition, the mixed-method design is valuable for understanding how errors can inform instructional strategies. However, like many studies in this domain, its focus on a specific unit limits its generalizability.

Studies by Arifin et al. (2020) and Widjajanti et al. (2019) contribute to exploring scaffolding strategies, focusing on the timing and implementation of scaffolding in problem-solving scenarios. While their qualitative methods provide detailed insights into scaffolding practices, the small sample sizes limit the broader applicability of their findings. These studies underscore the importance of understanding how different levels of academic ability and classroom contexts affect the efficacy of scaffolding, which remains a key area for further research.

Similarly, Tay and Toh (2023) proposed a model for scaffolding based on metacognitive strategies and problem-solving heuristics, grounded in established models by Polya and Schoenfeld. While their study offers practical examples of applying this model, challenges related to practical implementation in diverse classroom settings remain. This highlights the ongoing tension between theoretical frameworks and their real-world application—a gap many studies seek to bridge.

Finally, reviews like those by Bawadi et al. (2023) and Retnodari et al. (2020) offer broad overviews of scaffolding techniques across various educational levels, contributing to a more

comprehensive understanding of how scaffolding can support learners. However, as their general focus may dilute specific findings, more focused studies may better inform instructional practices.

Furthermore, the body of research reveals the importance of using multiple representations to deepen learners' understanding and address diverse learning needs. For instance, Jitendra et al. (2022) and Mainali (2021) underscore the theoretical significance of using concrete, semi-concrete, and abstract representations in mathematics education. However, both studies are primarily theoretical, lacking the empirical evidence needed to fully assess the impact of these strategies in real classroom settings. This theoretical foundation is echoed by Zhang et al. (2023), who demonstrate the real-world application of representational mapping in an online course, albeit with context-specific limitations restricting broader applicability.

Shifting to collaborative learning strategies, Pepkolaj et al. (2020) and Tachie (2022) provide valuable insights into the dynamics of cooperative models such as peer tutoring and collaborative learning, both of which positively influence classroom interaction. However, the absence of quantifiable data in these studies limits the generalizability of their findings. In contrast, Johnston (2021) and Walker et al. (2021) examine peer-led learning in specific contexts—applied mathematics workshops and digital collaboration platforms like Slack, respectively. Both studies offer practical insights into the benefits of peer collaboration, but their context-specific focus and reliance on self-reported data pose challenges for broader application.

Feedback, another critical element in mathematics education, is explored through different lenses in the literature. Rakoczy et al. (2019) present a robust cluster-randomised trial on the impact of formative assessment, while Hidayat et al. (2023) and Fiorentino and Montone (2022) focus on peer tutoring and feedback in formative assessment, respectively. Both studies emphasise the importance of feedback in improving learning outcomes. However, like earlier research, they are limited by a lack of longitudinal data or control groups that would allow for stronger empirical validation of their findings. Zheng and Tse (2023) explore the intersection of feedback and technology, examining the impact of AI-based formative feedback on learner motivation. While innovative, this study is constrained by a small sample size, limiting its generalizability.

Several studies, such as Langer-Osuna et al. (2020) and Campbell (2022), explore the dynamics of discourse and authority in collaborative learning environments, focusing on how these social elements influence group work in mathematics education. These studies provide deep theoretical insights but do not offer empirical data that can be readily applied to practice, emphasising a recurring theme across the literature: a need for more empirical research to support the theoretical frameworks that dominate the field.

This literature suggests that while strong theoretical support exists for using multiple representations, collaborative strategies, and feedback in mathematics education, the field would benefit from more empirical research exploring how these strategies translate into measurable improvements in learning outcomes across diverse educational settings. The literature provides a foundation for future research that could offer more robust, data-driven conclusions, particularly through longitudinal studies or controlled experiments that test these theoretical insights in broader and more diverse contexts. While these studies provide valuable insights into diagnostic assessments and scaffolding strategies, they also reveal the need for further exploration, particularly in diverse educational contexts and across different mathematical domains. The current study aims to build on these findings by focusing on the remedial strategies that Mathematical Literacy teachers employ to address learners' errors and misconceptions in Measurement which the existing literature has not yet fully explored.

2.4.2 Factors influencing teachers' engagement with learners' misconceptions and errors

This section reviews existing literature that focuses on factors influencing teachers' engagement with learners' misconceptions and errors.

2.4.2.1 Teachers' knowledge and confidence

The ability of a teacher to effectively address misconceptions in mathematics is influenced by their subject matter knowledge, pedagogical knowledge, and confidence. Teachers with a strong understanding of the subject are better equipped to recognise and address misconceptions (Moosapoor, 2023; Qian et al., 2020). The knowledge of new teachers concerning mathematical misconceptions is significantly associated with their ability to provide solutions to mathematical problems, highlighting the importance of a solid grasp of subject matter in effective teaching (Moosapoor, 2023). In addition to subject matter expertise, teachers with a good grasp of instructional strategies are more capable of engaging with and correcting misconceptions. Experience gained from professional teacher programs enhances

teachers' knowledge and skill for diagnosing and addressing learners' misconceptions (Juhaevah et al., 2020).

Furthermore, a teacher's confidence to manage classroom discussions and handle errors without disrupting the lesson plan is crucial (Qian et al., 2020). Qian et al. (2020) argues that a teacher who is confidence in their abilities to address learners' misconceptions have a more positive perception towards addressing learner misconceptions and effectiveness in the classroom.

2.4.2.2 Professional development

Access to ongoing professional development opportunities is crucial for teachers to develop their expertise to identify and address misconceptions effectively. One key element of professional development is mentorship. Having mentors and support from experienced colleagues encourages teachers to engage more actively with learners' errors and misconceptions (Handrianto et al., 2022; Kilag & Sasan, 2023). The research underscores the importance of mentoring for new teachers, who benefit significantly from guidance and support in their early years (Colognesi et al., 2020). New teachers prefer to select their mentors—ideally, close colleagues who teach the same course and year, as this proximity and relevance enhance the mentoring experience (Colognesi et al., 2020).

A lack of mentoring and development opportunities can cause teachers to hesitate to address learners' errors and misconceptions. Peer teaching and mentoring experiences have been shown to contribute positively to personal and professional development, fostering growth in teaching skills and self-confidence (Yang et al., 2022). Effective mentoring strategies involve teamwork, exchanging information, continuous learning, all of which enhance teachers' professional development (Handrianto et al., 2022).

Instructional leadership practices play a critical role in promoting teachers' learning and development. Instructional leaders can support teachers' professional growth by modelling effective teaching practices and facilitating collaboration (Kilag & Sasan, 2023; Ahmad et al., 2025). Additionally, ongoing professional development opportunities, such as workshops, mentoring, and coaching, are vital to fostering a culture of continuous improvement in teaching practices (Kilag & Sasan, 2023). Therefore, access to ongoing professional development, including mentoring and instructional leadership, is essential for teachers to be able to address learners' misconceptions effectively. Mentorship and support from experienced colleagues, tailored professional development strategies, and strong instructional leadership practices

collectively contribute to teachers' growth and their ability to engage more actively with learners' errors, ultimately enhancing the quality of education.

2.4.2.3 Beliefs and attitudes

Teachers' perceptions of errors during the learning process greatly influences their approach to addressing learners' misconceptions. Those who view errors as a natural and integral part of learning are more likely to address them constructively (Hoth et al., 2022). Teachers who believe all learners can learn and improve tend to invest more time addressing misconceptions (Breternitz & Tulis, 2024). However, discrepancies often exist between teachers' beliefs and their actual practices, as many avoid using errors as learning tools (Glovňová, 2020). Research indicates that teachers' ability to deal with learners' errors is primarily predicted by their constructivist beliefs. Moreover, their capacity to quickly identify typical errors largely depends on their mathematics content knowledge (Hoth et al., 2022).

Despite recognising the potential for errors in learning, teachers often change the subject or move on too quickly after an error occurs, thereby missing valuable opportunities for promoting learning (Köpfer, 2022). Furthermore, Köpfer (2022) found that learners and instructors avoided generating errors but emphasise learning from them when they occur. This highlights the need for a shift in attitudes and practices towards viewing errors as beneficial learning experiences (Pan et al., 2020). As such, while many teachers understand the theoretical value of learning from errors, there is a need for greater alignment between this belief and practical teaching strategies to fully harness the educational potential of errors.

2.4.2.4 Classroom dynamics

Research indicates that a positive and supportive classroom climate—fostered through effective classroom management—creates an environment of trust where students feel comfortable making and discussing mistakes, which in turn allows teachers to use errors as valuable learning opportunities (Soncini et al., 2020; Lee, 2022). Experienced teachers are better at recognizing and responding to classroom events, enabling them to maintain order and devote more attention to instructional strategies, including error correction and deeper engagement with student thinking (Wolff et al., 2021). Conversely, poor classroom management, such as inconsistent rules or frequent disruptions, can distract teachers from addressing errors effectively and limit opportunities for meaningful feedback and discussion (Karasova & Nehyba, 2025).

In a study conducted by Brundrett (2021), the majority of teachers believed smaller class sizes would enhance classroom management and allow for more individual attention for each learner. Reducing class size can significantly improve teacher-learner interactions and individualised instruction, improving learner behaviour, attitudes, and efforts (Laitsch et al., 2021). Research indicates that smaller class size positively impacts learners' performance, emphasising the importance of creating an optimal learning environment tailored to learners' needs (Nakamura & Dev, 2022). Hence, the consensus is that smaller class sizes contribute to better educational outcomes by allowing teachers to manage classrooms more effectively and provide more personalised instruction, thus addressing learners' errors more efficiently and fostering a conducive learning environment.

2.4.2.5 Flexible curriculum and assessment practices

Curricula that promote flexibility and adaptation play a crucial role in enabling teachers to spend time addressing misconceptions effectively. Teachers facing curricular changes require competencies to adapt their teaching methods and support such as training and resources to identify and correct misconceptions (Bongco & De Guzman, 2022).

Formative assessments are crucial in identifying learner misconceptions, enabling teachers to address these issues effectively (Martin et al., 2022; Enu & Ngcobo, 2020; Bansilal & Debba, 2012). Teachers can pinpoint gaps and errors in learners' understanding during instruction by utilising techniques such as feedback and formative questioning, allowing for timely intervention and clarification (Enu & Ngcobo, 2020).

2.4.2.6 Time constraints

Tight schedules and the pressure to cover extensive curricula can limit the time teachers have to address errors. Adequate preparation time allows teachers to plan for addressing misconceptions effectively. Research indicates that addressing learners’ errors in mathematics is crucial for learning, but time constraints can limit opportunities for error correction and providing meaningful feedback during lessons (Frank et al., 2020). Due to time constraints, teachers' often use teacher-centred, rather than learner-centred, approaches to address errors (Pinzón et al., 2022). While teachers recognize the importance of treating errors as learning opportunities to improve conceptual understanding, the limited time available often leads to a gap between identifying errors and actually addressing them (Hu et al., 2022).

Adequate time for preparation and planning is crucial, as it allows teachers to anticipate common misconceptions and design strategies to address them effectively. However, the demands of curriculum coverage and assessment requirements frequently force teachers to prioritize content delivery over in-depth error correction (Esmael & Rabut, 2025; Hu et al., 2022). Despite these challenges, teachers strive to balance curriculum demands with the need to address errors, but time limitations remain a persistent barrier to fully supporting student learning in mathematics (Esmael & Rabut, 2025; Hu et al., 2022).

2.4.2.7 Resources and support

The availability of teaching aids and resources is crucial to helping teachers address misconceptions. Effective teaching aids can help teachers explain complex concepts more clearly, reducing misunderstandings (Sun et al., 2022). Encouragement and support from school administration further empower teachers to focus on and correct learner misconceptions. Research shows that teachers are more inclined to remain in their positions when they receive strong administrative and collegial support, have access to instructional materials, and possess substantial experience (Bettini et al., 2020). Therefore, while adequate teaching resources and administrative support can significantly enhance a teacher's ability to address misconceptions, overcoming barriers such as insufficient resources and support remains essential for improving educational outcomes.

2.4.2.8 Technology

Technology can provide tools and resources for diagnosing and addressing misconceptions. Teachers' comfort and proficiency with technology can influence their ability to use it to address learners' errors. Teachers' qualifications and additional training in digital skills positively impact their confidence in addressing learner misconceptions and increase their perceived importance of these misconceptions (Qian et al., 2020). Furthermore, perceived technology skills and confidence in using technology significantly influence teachers' use of instructional and application software (Doğan et al., 2020).

However, the use of educational technology can also lead to high levels of anxiety and stress among teachers (Fernández-Batanero et al., 2021). School culture is a crucial predictor of teacher behaviour, suggesting that improving technology proficiency and school culture may foster better learner-teacher relationships (Catog, 2023). Teachers' motivational beliefs also play a crucial role in effectively applying technology to mathematics instruction (Backfisch et

al., 2020). This highlights the importance of not only technological proficiency but also the motivational beliefs of teachers in successfully integrating technology into their teaching practices.

2.4.2.9 Strengths and weaknesses of studies conducted on factors influencing teachers' engagement

The literature reveals various factors influencing teachers' engagement for addressing misconceptions and errors, and educational professional development, employing qualitative, quantitative, and mixed methods approaches. A study by Bansilal and Debba (2012) provided valuable insights into how Grade 12 learners engage with contextual attributes in ML assessments. Its strengths lie in its relevance to the ML curriculum, its qualitative approach, larger sample, and practical recommendations for improving assessment design. However, its limitations include a narrow focus on a single task, the absence of an exploration of instructional or socio-economic factors, and a limited discussion of mathematical content. Expanding the scope of the study to include diverse samples, multiple tasks, and a deeper analysis of both contextual and mathematical reasoning would enhance its contribution to the field of Mathematical Literacy education.

Qian et al. (2020) did expand on Bansilal and Debba's (2012) study; they qualitatively sampled learners and used an open-ended questionnaire to focus on high school teachers' perceptions of programming misconceptions. The broad, generalizable data provides a snapshot of teacher awareness, though it lacks depth into the intricacies of misconceptions. In contrast, Moosapoor's (2023) mixed-methods study on new elementary teachers' understanding of mathematical misconceptions in Iran combines quantitative and qualitative tools to offer a more comprehensive analysis. The study's regional specificity may limit generalisation.

Juhaevah et al.'s (2020) qualitative case study of two teachers' approaches to addressing mathematical misconceptions, offers detailed insights, though the small sample size restricts its broader applicability. Similarly, Kilag and Sasan (2023) explored the role of instructional leadership in teacher development through a thematic analysis of interviews, yielding rich, contextual data, but suffering from limited generalizability due to the small sample size. Such in-depth, qualitative analyses are useful for generating context-specific findings, but larger studies are often necessary to make broader generalisations.

Hoth et al. (2022) and Pan et al. (2020) extend these discussions to teachers' diagnostic skills and the pedagogical benefits of errors, respectively. Hoth et al.'s (2022) mixed-method approach involving video vignettes and speed tests offers a robust framework for evaluating diagnostic skills. Still, the artificial nature of the testing scenarios may limit real-world applicability. Pan's (2020) large-scale survey provides a comprehensive understanding of attitudes toward errors, yet the reliance on self-reported data risks introducing biases.

Colognesi et al. (2020) and Handrianto et al. (2022) explore mentoring as a factor in professional development. Colognesi's (2020) mixed-method study highlights the value of mentoring but also uncovers the complexities of hierarchical mentorship relationships. At the same time, Handrianto's (2022) literature review emphasizes key factors like teamwork and continuous learning but acknowledges the limitations of secondary data sources.

Finally, studies like those by Lee (2022) and Nakamura and Dev (2022) on class size effects provide a quantitative lens into instructional contexts, highlighting the nuanced relationships between teacher-learner interactions and classroom dynamics. While Lee's (2022) large, longitudinal dataset offers strong generalizability, Nakamura's (2022) simpler model underscores the complexity of educational research, which often requires more multifaceted approaches to capture all relevant variables.

Across these studies, a recurring theme is the balance between breadth and depth: while large-scale quantitative studies offer generalisable findings, qualitative approaches provide deeper, context-specific insights into teacher perceptions and strategies. Mixed-method studies bridge this gap, offering comprehensive overviews and detailed explorations of educational phenomena. However, the challenges of generalizability, potential biases, and the limitations inherent in both small-scale qualitative studies and broad surveys remain prevalent.

While prior studies provide valuable insights into common learner errors and misconceptions, they often lack a focus on the practical, classroom-based remedial strategies that teachers employ to address these issues in the subject of Mathematical Literacy, specifically. Additionally, limited attention is given to how contextual factors, such as resource constraints or curriculum pressures, impact teachers' ability to address learner misconceptions effectively. The current study aimed to build on these findings by focusing on the remedial strategies that ML teachers employ to address learners' errors and misconceptions in measurement, to provide

more context-specific insights that could directly inform teaching practices in South African classrooms.

2.4.3 Language and code-switching in Mathematical Literacy classrooms

Language plays a critical role in the teaching and learning of Mathematical Literacy in South Africa, where many learners' study mathematics in a language that is not their home language. Research conducted in South African classrooms has consistently highlighted language as a key factor influencing learners' ability to interpret mathematical problems, articulate reasoning, and engage meaningfully with mathematical concepts (Wilson & Mavor, 2023; Setati et al., 2002; Mavuru & Ramnarain, 2020).

Mathematical Literacy places particular emphasis on interpreting real-life contexts, analysing textual information, and translating everyday situations into mathematical representations (Venkat & Graven, 2006; 2014). As a result, learners' comprehension of language within word problems and contextual tasks becomes central to their mathematical performance. Studies have shown that difficulties with language can lead learners to misinterpret questions, misunderstand key mathematical terminology, or incorrectly translate contextual information into mathematical procedures (Wilson & Mavor, 2023).

In multilingual South African classrooms, teachers frequently employ **c**ode-switching, moving between English and learners' home languages to clarify concepts and support understanding (Setati et al., 2002; Probyn, 2019;). Code-switching has been shown to function as an important pedagogical strategy, enabling teachers to scaffold learning by explaining complex concepts in familiar linguistic forms while maintaining access to formal mathematical terminology.

However, the use of multiple languages in the classroom also presents challenges. Teachers must balance the need to support learners' conceptual understanding with the expectation that national examinations are written in English. Venkat and Graven (2014); Abdalgane and Elnahdi (2024); Homad et al. (2025) and Woltan and Schwab (2025) argue that this tension places additional demands on Mathematical Literacy teachers, who must simultaneously teach mathematical reasoning and support learners' language development.

These studies highlight that language is not merely a communication tool in mathematics classrooms but a central component of learners' conceptual development. Consequently, teachers' ability to recognise and respond to language-related misunderstandings becomes an important dimension of addressing learner misconceptions. This issue is particularly relevant

in the context of Mathematical Literacy, where contextual interpretation and verbal reasoning are integral to problem solving.

2.5 Chapter summary

This chapter has reviewed the literature relevant to the research topic. The literature review provided an extensive overview of previous research on learners' misconceptions and errors, as well as the strategies used by teachers to address these issues and the factors influencing their engagement or lack of engagement with learners' misconceptions and errors.

The review of the literature identified several key themes and findings on the topic of addressing learners' misconceptions and errors in Measurement in the Mathematics Literacy subject. The literature highlights the significant role that teachers' professional knowledge and beliefs play in effectively addressing learners' misconceptions. Despite these findings, notable gaps in the literature warrant further exploration. For instance, while several studies emphasise the importance of professional knowledge and social networks, there is limited research on how these factors interact with specific teaching strategies tailored to address misconceptions in Measurement in ML. Moreover, the reviewed studies often focus on general educational contexts, leaving a gap in understanding the unique challenges and effective strategies within diverse classroom settings and educational systems.

This literature review contributes to the broader research project by synthesising existing knowledge and identifying critical areas for further exploration. Addressing learners' misconceptions and errors in Measurement is crucial for improving their mastery of ML and their overall educational outcomes. Teachers can better support learners' learning by understanding and addressing these misconceptions, leading to higher mathematical proficiency and confidence levels (Mbonambi & Bansilal, 2014). The insights gained from this review underscore the need for continued research and innovation in teaching practices to meet the evolving demands of education. The following chapter presents the theoretical framework underpinning this study.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1 Introduction

The previous chapter reviewed the literature relevant to this study. This chapter presents the theoretical framework that guided this study. A theoretical framework provides a foundational structure to guide research by outlining a study's essential concepts and relationships. It supports the inquiry process while positioning the research within a broader academic context, enhancing its credibility and aiding comprehension (Elsherif, 2024). By defining the research problem and identifying relevant variables, a theoretical framework contributes methodological rigour, contributing to the overall soundness of the study (Salinas-Atausinchi et al., 2023; Liu & Gatzweiler, 2024).

While theoretical frameworks help to structure and guide research, some scholars contend that they may confine research to established paradigms, which could stifle innovation and limit fresh approaches to inquiry (Heikkinen et al., 2024). This concern is particularly relevant in educational research, where rigid adherence to a single theoretical perspective can obscure alternative interpretations or novel strategies for addressing learning challenges (Heikkinen et al., 2024). In this study, constructivism was chosen as a flexible and dynamic lens through which to explore how Mathematical Literacy teachers engage with learners' errors and misconceptions in Measurement.

Constructivism posits that learners construct their own understanding and knowledge through their experiences and interaction with the world (Piaget, 1977; Vygotsky, 1978). This theory is particularly relevant to this study as it offers insights into how learners' misconceptions can arise and how teachers might engage with these misconceptions to facilitate more accurate understanding.

This chapter presents the theoretical framework guiding the study. The chapter introduces constructivism, traces its historical development, and discusses its key principles in relation to teaching and learning. Particular attention is given to the contributions of Piaget and Vygotsky, whose work informs the study's understanding of how learners construct knowledge and how teachers can support conceptual development. The chapter concludes by explaining how constructivist principles inform the interpretation of learner misconceptions and teachers' remedial strategies in the teaching of Measurement in Mathematical Literacy.

3.2 The origins and development of constructivism

Constructivism, as a theory of knowledge and learning, has deep historical roots in the fields of philosophy, psychology, and education. Constructivism emerged as a response to behaviourist models of learning, which conceived knowledge as something that is transmitted from teacher to learner (Sulistyo, 2020). Hence, it is grounded in the understanding that knowledge is not passively received but actively constructed by individuals through their engagement with the world (Abha, 2019; Topolovčan, 2023). In this view, cognition serves to organise and interpret experience rather than to uncover an objective or absolute reality. Over time, constructivism has evolved from a set of philosophical ideas about the nature of knowledge into a robust theory that informs contemporary educational practices. This section discusses the historical context of the origins and development of constructivism.

3.2.1 Philosophical origins

The earliest traces of constructivist thinking can be found in the works of ancient Greek philosophers, particularly Socrates and Plato, who emphasised inquiry and reflective dialogue as pathways to understanding. These ideas were paralleled by Eastern philosophical traditions, including the teachings of Gautama Buddha, which similarly highlighted active engagement and personal reflection in the pursuit of knowledge (Abha, 2019; Topolovčan, 2023). In the early modern period, philosophers such as René Descartes, John Locke, David Hume, Giambattista Vico, and Immanuel Kant expanded these ideas by asserting that human knowledge is shaped by the activity of the mind rather than by passive reception of external facts (Abha, 2019; Topolovčan, 2023).

3.2.2 18th–19th Century developments

The 18th century marked a significant turning point in the articulation of constructivist ideas. Giambattista Vico explicitly formulated a constructivist theory in 1710, arguing that to know something is to understand how it is constructed. This was a radical departure from purely empiricist perspectives, positioning the knower as an active agent in the production of knowledge. Immanuel Kant further developed this line of thought by proposing that human beings actively organise their experiences through innate cognitive structures. These contributions established the intellectual foundation for modern constructivism and shifted the discourse on knowledge from objective discovery to subjective construction (Abha, 2019; Topolovčan, 2023).

3.2.3 Integration into the field of psychology

In the 20th century, the field of psychology applied the philosophical theory of constructivism to an understanding of human learning. This shift was largely driven by the work of developmental psychologists such as Jean Piaget and Lev Vygotsky in the 1970s, who provided systematic accounts of how individuals construct knowledge. Piaget focused on cognitive development through active learning and emphasised how learners interact with their environment to build understanding (Piaget, 1977; Mulyadi, 2022). Vygotsky complemented this view by stressing the social and cultural context of learning, highlighting how interaction with others and cultural tools mediate knowledge construction (Vygotsky, 1978; Alanazi, 2016). Together, their work positioned constructivism as a central paradigm in educational theory and research.

3.2.4 Application to the field of education

Around the same time, reformist educators such as John Dewey began to integrate constructivist principles into progressive educational movements. Dewey argued for student-centred and inquiry-based learning, in which learners actively participate in constructing knowledge through exploration and reflection, rather than memorising static information (Topolovčan, 2023; Popkewitz, 1998).

In the contemporary field of education, constructivism underpins a wide range of teaching and learning approaches that emphasise active engagement, collaborative learning, and reflective practice. Teachers are viewed less as transmitters of knowledge and more as facilitators of learning, creating conditions that enable students to build meaning for themselves (Topolovčan, 2023; Chand, 2023). These principles have had a profound impact on curriculum design, assessment practices, and pedagogical strategies worldwide.

Table 1 summarises the key historical milestones in the development of constructivism. The table highlights major periods, key figures, and their contributions to the theory, offering a concise overview of the evolution outlined in this section.

Table 1

Summary of key historical developments

Period	Key Figures/Ideas	Contribution to Constructivism

Ancient to medieval period	Socrates, Plato, Buddha	Early ideas about the construction of knowledge
18th–19th Century	Vico, Kant, Locke, Hume	Mind organizes experience
1970's	Piaget, Vygotsky, Dewey	Cognitive and social constructivism
Contemporary period	Educational reform, cognitive science	Student-centered, inquiry-based learning

The historical trajectory of constructivism reflects its evolution from early philosophical explorations to a foundational framework in psychology and education. Rooted in the works of classical philosophers and refined through the contributions of thinkers such as Vico, Kant, Piaget, Vygotsky, and Dewey, constructivism underscores the idea that knowledge emerges through active engagement, reflection, and social interaction (Mulyadi, 2022; Alanazi, 2016; Piaget, 1977; Vygotsky, 1978; Topolovčan, 2023; Chand, 2023). Its enduring influence continues to shape modern educational thought and practice, making it a powerful theoretical lens for understanding how learning takes place in dynamic and contextually embedded ways. This historical grounding provides a basis for exploring the main branches and principles of constructivism.

3.3 Branches of constructivism and theoretical tensions

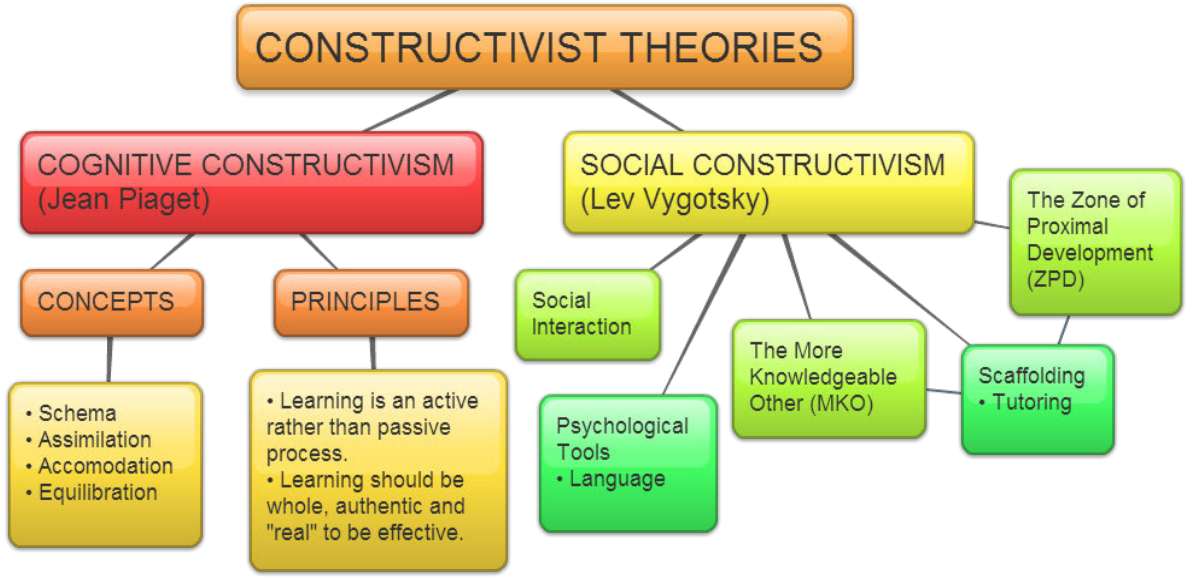
This section discusses the two main theoretical branches of constructivism and their key concepts, together with several tensions that have challenged its coherence and application. Additionally, a comparison of constructivism with two other theories—behaviourism and cognitivism—is provided to demonstrate the relevance and value of constructivism over other theories as a theoretical framework for this study.

Constructivism has developed into two primary theoretical branches: cognitive constructivism and social constructivism. These two strands are conceptually distinct but complementary (Kalpana, 2014; Main, 2021; Tanjung et al., 2023). Cognitive constructivism focuses on how individuals build knowledge through internal cognitive processes, while social constructivism emphasises the mediating role of social interaction, language, and cultural tools in learning (Piaget, 1977; Vygotsky, 1978). Figure 2 provides a visual overview of the main branches of constructivism and their relationship to teaching and learning processes. The diagram illustrates how cognitive and social perspectives of constructivism inform the

interpretation of learner misconceptions and the role of teacher mediation in supporting conceptual understanding.

Figure 2

Visual overview of the branches of constructivism, (adapted from Golder & Bengal, 2018, p. 680)



3.3.1. Cognitive constructivism

Cognitive constructivism centres on the idea that learners construct their own understanding of the world through interaction with their environment. According to Piaget (1977), learners approach new experiences with existing mental frameworks, known as schemata. Schemata act as cognitive structures that help individuals organise and interpret information (Golder & Bengal, 2018; Chand, 2023). When encountering new information, learners either assimilate it into their existing schemata or accommodate their schemata to integrate the new experience (Chand, 2023; Golder & Bengal, 2018; Piaget, 1977). This dynamic process allows learners to continually reorganise their understanding as they encounter unfamiliar or challenging ideas.

Another key concept in Piaget's theory is equilibration, which refers to the balance between assimilation and accommodation (Golder & Bengal, 2018; Kumari, 2022; Piaget, 1977). When new information fits well into existing schema, equilibrium is maintained. When it does not, learners experience cognitive disequilibrium, which motivates them to adjust their understanding through accommodation, thereby achieving a new state of balance (Chand, 2023; Golder & Bengal, 2018). This process of equilibration is fundamental to cognitive growth and learning (Piaget, 1977).

Importantly, Piaget (1977) argues that learning is most effective when it is authentic and connected to real-world experiences. Knowledge construction occurs within meaningful contexts, and learners build deeper understanding when they can relate abstract concepts to their lived experiences (Chand, 2023; Golder & Bengal, 2018). In the classroom, this implies that learners should be actively engaged in hands-on, problem-solving tasks that encourage them to make sense of new mathematical or scientific ideas through exploration and inquiry (Golder & Bengal, 2018).

3.3.2 Social constructivism

While Piaget's work foregrounds internal cognitive processes, social constructivism, based on the work of Vygotsky (1978) highlights the central role of social interaction in the construction of knowledge. Vygotsky (1978) argues that learning is fundamentally a social process that occurs through interaction with others and the use of cultural tools, particularly language. Through dialogue, negotiation, and collaboration, learners co-construct knowledge, which is then internalised at the individual level (Golder & Bengal, 2018).

A cornerstone of Vygotsky's theory is the Zone of Proximal Development (ZPD), defined as the gap between what a learner can achieve independently and what they can achieve with appropriate guidance and support (Zaretsky, 2021; Vygotsky, 1978). Within this zone, learning is optimised when learners work with a More Knowledgeable Other (MKO), such as a teacher, peer, or mentor, who provides structured support (Zaretsky, 2021; Vygotsky, 1978). This support is known as scaffolding, which involves offering temporary assistance that enables learners to accomplish tasks they would not be able to complete alone (Wei, 2024). As learners gain competence, the scaffolding is gradually withdrawn, fostering autonomy and deeper understanding (Bada & Olusegun, 2015; Golder & Bengal, 2018; Wei, 2024).

Social constructivism also emphasises the collaborative nature of learning. Knowledge is co-constructed through shared experiences, group problem-solving, peer discussions, and interactive activities (Golder & Bengal, 2018; Brau, 2020). These social processes create opportunities for learners to test ideas, reflect, and negotiate meaning, leading to more robust and lasting learning outcomes. From this perspective, the classroom becomes a community of enquiry, where teachers act as facilitators who guide learners' thinking—rather than as the sole transmitters of information (Golder & Bengal, 2018; Brau, 2020).

Unlike traditional views of learning, which see knowledge as a fixed entity to be transmitted from teacher to learner, constructivism emphasises the learner's role in creating meaning (Bada & Olusegun, 2015). Reflection is a key component of the learning process. Learners are encouraged to think about their thinking—a process termed 'metacognition'—and reflect on their learning experiences to deepen their understanding. Constructivist teaching methods often include hands-on activities, collaborative projects, discussions, and real-world problem-solving tasks (Subba et al., 2025; Hong & Han, 2023). These methods engage learners in active exploration and construction of knowledge. Table 2, contrasts features of traditional and constructivist classrooms.

Table 2

Comparison of characteristics of traditional and constructivist classrooms (adapted from Bada & Olusegun, 2015, p. 68-69)

Traditionalist classroom	Constructivist classroom
The curriculum begins with the parts of the whole. Emphasises basic skills.	The curriculum emphasises big concepts, beginning with the whole and expanding to include the parts.
Strict adherence to a fixed curriculum is highly valued.	The pursuit of learners' questions and interests is valued.
Materials are primarily textbooks and workbooks.	Materials include primary sources such as textbook, workbooks and manipulative materials.
Learning is based on repetition.	Learning is interactive, building on what the learner already knows.
Teachers disseminate information to learners; learners are recipients of knowledge.	Teachers have a dialogue with learners, helping learners to construct their own knowledge.
The teacher's role is directive and authoritative.	The teacher's role is interactive and fosters negotiation.
Assessment is conducted through testing for **correct answers.**	Assessment includes evaluation of learners' work, observations, and tests. The process is as important as the product.
Knowledge is seen as inert.	Knowledge is seen as dynamic, changing as the learner encounters new experiences.

Learners work primarily alone.	Learners work primarily in groups.

3.3.2 Tensions within constructivism

While influential in educational theory, constructivism presents several tensions that have challenged its coherence and application. These tensions arise from the diverse interpretations and implementations of constructivist principles, leading to inconsistencies in pedagogical practices and theoretical foundations.

3.3.2.1 Subjectivity and objectivity of knowledge

Constructivism posits that learners construct their understanding through experience and reflection, implying that knowledge is subjective (Piaget, 1970). However, this subjective construction of knowledge contrasts with the objective nature of scientific knowledge, where universally accepted truths exist (Phillips, 1995). Critics argue that constructivism can lead to relativism, suggesting that all interpretations of knowledge are equally valid, which can undermine objective assessment (Nola, 1998).

3.3.2.2 Role of the teacher and autonomy of the learner

Constructivism emphasises learner autonomy and the minimisation of teacher intervention (Vygotsky, 1978). However, effective learning often requires guidance, particularly in complex subjects. This contradiction is evident in Vygotsky's (1978) own work, which suggests that a 'more knowledgeable other' is necessary to scaffold learning. Balancing teacher guidance with learner autonomy can be challenging, especially when learners struggle to self-direct (Kirschner et al., 2006).

3.3.2.3 Teaching and assessment

Constructivist approaches value process over product, focusing on the learner's journey rather than solely on outcomes (Fosnot, 2013). Yet educational systems often rely on standardised assessments, creating a contradiction in evaluating constructivist learning environments. This tension between constructivist pedagogy and assessment has led to debates about whether standardised testing is appropriate or fair in constructivist contexts (Torrance & Pryor, 2001).

3.3.2.4 Practical challenges of implementation

Constructivism assumes that learners can self-regulate and construct knowledge independently, yet not all learners are equipped to do this effectively (Mayer, 2004). Additionally, implementing constructivist approaches in diverse classrooms can be impractical, as it often demands more time, resources, and individual support than do traditional methods (Kirschner et al., 2006).

3.3.2.5 Sociocultural vs. cognitive focus

Constructivist theory includes multiple strands, such as Piaget's cognitive constructivism and Vygotsky's sociocultural constructivism, which emphasise individual cognition and social interaction, respectively. This dual focus creates a theoretical divide, as each strand prioritises different mechanisms for knowledge construction (Prawat, 1996). The difficulty reconciling these views within a unified constructivist framework leads to inconsistencies in the application of theory (Cobb, 1994).

3.3.2.6 Incoherence practices

Many teachers claim to adopt constructivist approaches; however, their actual pedagogical practices often reflect a mix of paradigms, leading to a lack of coherence (Vargas & Acuña, 2020). This means that teachers may hold conflicting epistemological beliefs, which can hinder their effectiveness in achieving the desired teaching and learning outcomes.

3.3.3 Comparison of constructivism with behaviourism and cognitivism

To explore the relevance and value of constructivism as a theoretical framework for this study over other theories, this section briefly compares it with behaviourism and cognitivism. These theories differ significantly from constructivism in how they conceptualise the role of the teacher and the development of learners' understanding.

Behaviourism focuses on observable behaviours, emphasising learning as a process through which learners are conditioned using reinforcement and punishment (Skinner, 1974; Ashfia & Septianti, 2024). According to this theory, learners passively absorb information presented by the teacher, and learning is measured through changes in behaviour (Ashfia & Septianti, 2024; Petri & Mishkin, 1994). For Mathematical Literacy teachers addressing learners' misconceptions in Measurement, a behaviourist approach would involve drills and repetitive practice to correct errors. However, this theory does not account for the cognitive processes

underlying misconceptions or the active engagement learners need to reconstruct their understanding. Since behaviourism treats learning as a product of environmental stimuli, it may not provide the necessary framework for addressing deep-seated misconceptions, as it focuses more on outcomes than conceptual change processes.

Cognitivism, on the other hand, centres on the mental processes involved in learning. It suggests that learning occurs when the brain processes, stores, and retrieves information (Neisser, 1967; Petri & Mishkin, 1994). While cognitivism acknowledges the importance of prior knowledge and memory in learning, it still views learning as a primarily internal cognitive process that can occur independently of social interaction (Petri & Mishkin, 1994; Muhajirah, 2020). Cognitive theories such as information processing theory emphasise how learners encode, process, and store information, but may not adequately explain how social and contextual factors—which are crucial elements in constructivism—help learners overcome misconceptions in areas like Measurement. Although cognitivism recognises mental schemata—which is similar to constructivism—it lacks a strong focus on interaction with the environment and others as key to constructing understanding.

In contrast, constructivism emphasises that learning is an active, social process where learners construct knowledge based on prior experiences, engagement, and reflection (Piaget, 1977; Vygotsky, 1978). Unlike behaviourism, which emphasises external control, and cognitivism, which focuses on internal cognitive processes, constructivism situates learning in real-world contexts. It highlights the role of interaction and dialogue in overcoming misunderstandings. This is particularly relevant to remedial strategies in Mathematical Literacy, as learners must actively engage with both their misconceptions and their peers' perspectives to reconstruct their understanding of Measurement concepts. Vygotsky's (1978) concept of the zone of proximal distance (ZPD) encapsulates the notion that learners learn best when scaffolded by teachers and peers who help them navigate difficult concepts—such as units of measurement and conversions.

3.4 Application of constructivism to this study

Constructivism, with its emphasis on the learner's active role in constructing knowledge through engagement and social interaction, underpins both the analytical framework and the research design of this study. Constructivist concepts guided the exploration of how Mathematical Literacy teachers addressed learners' misconceptions and errors in

Measurement. In particular, the principles of assimilation, accommodation, scaffolding, active learning, social interaction, reflection, and learner-centred engagement informed how data were collected, interpreted, and analysed.

Constructivism, as a theoretical framework, thus shaped not only how meaning was made from teachers' practices but also how the instruments were designed to elicit data aligned with constructivist assumptions about knowledge construction.

3.4.2 Application of constructivist principles to design data collection instruments

The design of the data collection instruments—the interview schedule, classroom observation protocol, and document analysis guide—was informed by constructivism, ensuring that each tool elicited evidence of teachers' engagement with learners' knowledge-building processes. The principles of active participation, social mediation, and contextual learning guided how questions and observation criteria were structured.

3.4.2.1 Interview schedule

The semi-structured interview questions (Appendix C) were designed to capture teachers' interpretations of learners' misconceptions and their reasoning for selecting particular remedial strategies. On the interview schedule, Section B focused on identifying how teachers identify misconceptions, reflecting the constructivist concern with diagnosing learners' pre-existing cognitive frameworks. Section C explored how teachers engage learners in conceptual change through questioning, peer discussion, and collaborative activities, while Section D examined the motivations and reflective practices that influence teachers' engagement with misconceptions. These interview prompts align with the constructivist principle that knowledge develops through reflection, dialogue, and context-sensitive teaching.

3.4.2.2 Classroom observation protocol

The lesson observation protocol (Appendix D) was structured to document real-time evidence of active learning, social interaction, and scaffolding in practice. Criteria such as lesson introduction (eliciting prior knowledge), teacher response to misconceptions, and learner engagement were derived from constructivist tenets. Observations focused on whether teachers facilitated peer learning, prompted reflective questioning, or used hands-on demonstrations—practices that operationalise the ZPD and promote meaningful learning.

3.4.2.3 Document analysis protocol

The document analysis protocol (Appendix E) enabled the identification of misconceptions and teachers' written feedback as evidence of constructivist engagement. It examined whether teachers' comments were corrective, supportive, or scaffolding-oriented, and whether they guided learners toward self-correction or reflection. By analysing learners' test scripts and assignments, and DBE diagnostic reports, the study sought to trace how written feedback functioned as a medium of scaffolding and cognitive reorganisation, consistent with Piaget's and Vygotsky's theoretical propositions.

Across all three instruments, the application of constructivist principles ensured that data collection focused on the processes of meaning-making, not merely outcomes. Teachers were viewed as facilitators who create conditions for learners to explore, test, and reconstruct knowledge, while learners were regarded as active participants in their own conceptual growth. This alignment between theory, design, and analysis provided coherence to the study and reinforced the value of constructivism as a theoretical and methodological lens.

This integration of constructivist principles into both the analytical framework and research design enabled a comprehensive understanding to be gained of how Mathematical Literacy teachers address misconceptions in Measurement. Constructivism thus served not only as a lens for interpreting classroom interactions and remedial strategies but also as the guiding philosophy shaping the instruments that generated the data. Through this integration, the study remained aligned with its epistemological stance that knowledge is actively, socially, and reflectively constructed (Piaget, 1977; Vygotsky, 1978; Bada & Olusegun, 2015; Bruner, 1966).

3.4.1 Application of constructivist principles to data analysis

The analytical use of constructivism centred on understanding how teachers' practices reflected processes of knowledge construction. Learners' misconceptions were viewed as evidence of prior cognitive structures rather than as failures, and teachers' interventions were interpreted as scaffolding acts facilitating conceptual change (Piaget, 1977; Vygotsky, 1978; Bada & Olusegun, 2015).

3.4.1.1 Assimilation, accommodation, and equilibrium

Piaget's (1977) concepts of assimilation and accommodation offer a theoretical basis for understanding why learners develop misconceptions in measurement and how teachers can facilitate conceptual change. When learners encounter new measurement concepts, they

attempt to fit them into their existing schemata (which comprises their prior knowledge and experiences). If these schemata are incomplete or flawed, misconceptions may arise (Golder & Bengal, 2018). Remedial strategies, therefore, must involve deliberately designing instructional experiences that challenge these flawed schemata, creating opportunities for learners to restructure their understanding through accommodation and restore cognitive balance through equilibration. Thus, Piaget's constructs of assimilation and accommodation were employed to interpret how teachers' remedial actions helped learners reconcile their existing incorrect or incomplete schemata with new, accurate mathematical concepts. When teachers designed interventions that required learners to re-evaluate their reasoning or test alternative strategies, these moments were analysed as cognitive accommodation processes (Golder & Bengal, 2018).

Strategies such as teachers guiding learners through questioning, exploration, and hands-on activities, enabling them to actively reconcile prior and new knowledge, align with the study's aim of analysing how teachers support learners to refine their conceptual understanding of measurement concepts such as units, conversions, and scale.

3.4.1.2 Scaffolding and the Zone of Proximal Development

Vygotsky's (1978) concept of the Zone of Proximal Development (ZPD) provides a powerful theoretical foundation for understanding how teachers facilitate learning through interaction and guided support. The ZPD represents the distance between what ML learner can achieve independently in measurement—referred to as the actual developmental level—and what they can accomplish with the assistance of a more knowledgeable other, such as a ML teacher, or other ML peers. It highlights that meaningful learning occurs within this "zone," where measurement tasks are challenging enough to promote cognitive growth but not so difficult that they overwhelm the learner.

Within this framework, scaffolding becomes the mechanism through which learning in the ZPD takes place. This support is intentionally structured to match each learner's developmental level and is gradually reduced as the learner gains mastery and confidence in measurement (Bada & Olusegun, 2015). The process exemplifies Vygotsky's belief that learning is inherently social and collaborative—knowledge emerges through interaction and shared problem-solving rather than through isolated individual effort.

In this study, the ZPD framework was applied to understand how Mathematical Literacy teachers guide learners in overcoming misconceptions and errors in Measurement. When learners struggle with complex ideas—such as unit conversions, interpreting scales, or distinguishing between area and volume—teachers function as the more knowledgeable others who provide carefully calibrated support. This may include prompting learners to articulate their reasoning, modelling accurate procedures, or designing guided practice activities that progressively increase in complexity. As learners begin to internalise the correct concepts, teachers gradually withdraw assistance, enabling students to perform the tasks independently.

Such scaffolded engagement ensures that learners are neither disengaged by simplicity nor discouraged by difficulty. Instead, they operate within their optimal learning zone, where the teacher's support bridges the gap between prior misconceptions and newly constructed understanding. Through this guided process, learners not only correct their measurement errors but also develop greater autonomy, metacognitive awareness, and confidence in applying mathematical concepts to real-world contexts.

3.4.1.3 Active participation, social interaction and reflection

A defining feature of constructivism is its emphasis on active participation in learning. Therefore, ML learners deepen their understanding through interaction with measurement concepts, peers, and teachers rather than through passive reception of information (Golder & Bengal, 2018; Vygotsky, 1978). This active engagement is especially valuable in addressing measurement misconceptions, as it encourages learners to verbalise their reasoning, confront errors, and reconstruct their understanding.

Social interaction further amplifies this process. When learners collaborate—through discussions, group work, or problem-solving—they negotiate meaning, test their ideas, and reflect on their reasoning, leading to more robust conceptual development in measurement (Kalina & Powell, 2009). Reflection and metacognition also play a crucial role: when learners think about their thinking, they become aware of their errors and assumptions, which supports conceptual change.

In this study, teachers' use of collaborative learning tasks and reflective questioning were analysed as a key mechanism for promoting these processes. Through this theoretical framing, the data analysis focused on the process of conceptual change rather than on measuring correctness. Teachers' responses to learner misconceptions were interpreted in terms of how

effectively they created opportunities for assimilation, scaffolding, and reflection—key indicators of constructivist learning.

3.4.1.4 Diagnosing misconceptions and the role of constructivism

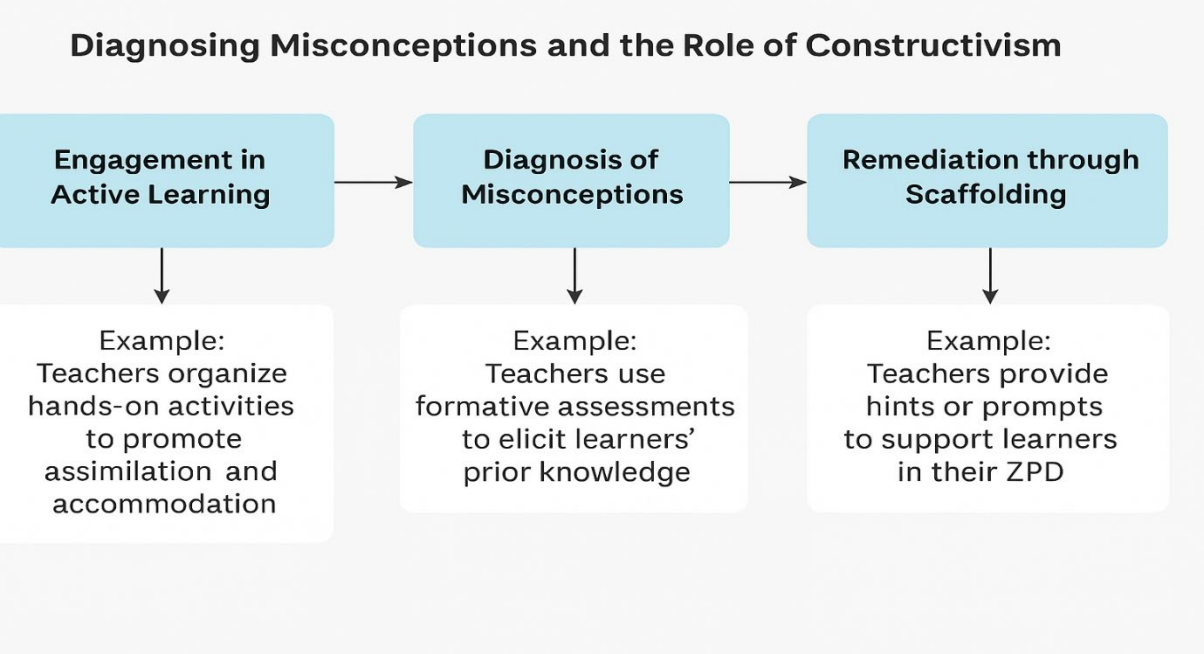
Before teachers can remediate misconceptions, they must first diagnose them. Constructivist theory assists in this process by highlighting strategies such as eliciting prior knowledge, where teachers use diagnostic assessments, questioning, or discussion to uncover learners' existing misconceptions. In addition, teachers can use formative assessment techniques such as continuous assessment practices like think-pair-share, concept maps, or error analysis, which allow teachers to gauge learners' understanding in real time and identify misconceptions.

1) **Engagement in active learning.** The framework helps interpret how teachers designed learning experiences that encouraged assimilation (integrating new information into existing schemas) and accommodation (restructuring schemas to accommodate new, accurate information). The study analysed strategies like interactive discussions, problem-solving tasks, or hands-on activities that support this process.
2) **Diagnosis of misconceptions.** Constructivism highlights the importance of eliciting learners' prior knowledge to uncover misconceptions. Teachers' use of diagnostic tools such as formative assessments, questioning, or error analysis was examined to see how they identified learners' misconceptions in Measurement.
3) **Remediation through scaffolding.** Vygotsky's concept of scaffolding is central to understanding how teachers support learners in moving through their ZPD. Findings were interpreted by analysing how teachers provided incremental support (e.g., hints, prompts, or guided practice) to help learners correct their misconceptions.

The diagram in Figure 3 demonstrates the sequence of engagement, diagnostic and remediation stages in Mathematical Literacy.

Figure 3

Sequential use of constructivist principles for the analysis of data in this study



3.12 Chapter summary

This chapter has presented the theoretical foundation underpinning this study. Constructivism was traced from its philosophical origins in ancient and modern thought through its formal development in the psychological theories of Piaget and Vygotsky, who respectively advanced cognitive and social constructivism. These two branches collectively explain how knowledge is actively built through interaction with the environment and through collaboration, dialogue, and cultural mediation.

The chapter outlined how constructivism provides a dynamic lens through which to interpret learning not as the passive reception of information but as an active, reflective, and socially mediated process. It explored key concepts such as assimilation, accommodation, equilibration, scaffolding, the Zone of Proximal Development (ZPD), active learning, social interaction, and reflection, showing how these principles illuminate the processes by which learners correct misconceptions and construct new understanding. The chapter also acknowledged internal tensions within constructivism, including debates over subjectivity and objectivity, teacher guidance versus learner autonomy, and the challenge balancing constructivist pedagogy with standardised assessment. These tensions were critically examined to position constructivism as both a flexible and pragmatic framework for this study.

Constructivism was then applied to the present research at two levels. First, as a design framework, it informed the development of the data collection instruments for interviews, classroom observations, and document analysis. Each instrument was structured to elicit evidence of teachers' constructivist practices, such as eliciting prior knowledge, facilitating reflection, and providing scaffolded support. Second, constructivism was applied as an analytical lens, guiding the interpretation of teachers' remedial strategies to reveal how engagement, diagnosis, and scaffolding were implemented to foster conceptual change among learners.

In uniting these theoretical and methodological dimensions, the chapter demonstrated that constructivism not only deepened the understanding gained through the study of how misconceptions arose and were addressed in Mathematical Literacy but also ensured coherence between the study's epistemological stance, research design, and analytical approach. Ultimately, the framework underscores that learning is an evolving, socially embedded, and reflective process, an insight that guides both the interpretation of findings and the development of effective remedial strategies.

The next chapter builds on this theoretical foundation by detailing the research methodology, explaining how the constructivist framework shaped the choice of research design, data collection procedures, and analytical methods employed in this study.

CHAPTER 4: METHODOLOGY

4.1 Introduction

The previous chapter presented the theoretical framework used in this study. This chapter presents the research methods used in this study, the rationale for choosing these methods, and how they were applied in the study. A research methodology directs the implementation of the study to address the research topic and achieve the study's goals and objectives (Nayak & Singh, 2021). To identify and design an appropriate, justifiable methodological approach for the study, the researcher was guided by the problem statement and the overarching research question.

The chapter begins by situating the research methods within the broader interpretivist paradigm, discussing why the interpretivist paradigm was appropriate for this study and elaborating on its ontological, epistemological, and axiological assumptions. The chapter then presents the research approach and design, explaining how these align with the study's objectives and qualitative orientation. The research context, population, and sample are described.

The chapter presents the data collection methods, discussing the specific methods and instruments employed, the piloting process used to refine these tools, and the data collection plan that ensured systematic and coherent implementation. This is followed by an explanation of the data analysis and presentation procedures, describing how meaning was constructed from the data to address the research questions. To ensure rigour and trustworthiness, the chapter also presents the quality assurance strategies adopted, focusing on credibility, transferability, dependability, and confirmability. The study's limitations are discussed along with the ethical issues considered throughout the research process to protect participants and uphold academic integrity. The chapter concludes with a summary that integrates these methodological components, establishing a coherent foundation for the analysis and interpretation presented in subsequent chapters.

4.2 Interpretivist paradigm

In the context of research, a paradigm refers to the overarching worldview or set of assumptions that guides how knowledge is understood, generated, and interpreted. It provides a philosophical foundation that informs how researchers frame problems, select methods, and interpret findings (Bila, 2024; Shakespeare, 2022; Fasoli, 2020; Steinert, 2020; Saunders et al.,

2019). Paradigms are therefore essential to ensure coherence between a study's ontological, epistemological, and methodological choices, shaping how phenomena are approached and understood.

While the theoretical framework—in this study, constructivism—provides a conceptual lens for interpreting findings, the paradigm provides the philosophical foundation that shapes how data is collected, analysed, and understood. Together, they ensure methodological alignment: the paradigm guiding the research worldview and the theoretical framework informing the interpretation of phenomena.

This study is underpinned by the interpretivist paradigm, which emphasises understanding social reality through the meanings individuals ascribe to their experiences. Rather than seeking objective, generalisable truths, interpretivism values subjective perspectives and context-specific interpretations, recognising that knowledge is co-constructed between the researcher and participants (Fasoli, 2020; Shakespeare, 2022; Cohen et al., 2018). This paradigm is particularly suited to exploring remedial strategies employed by Mathematical Literacy teachers because it allows for in-depth engagement with their lived experiences, beliefs, and classroom practices, thereby revealing how they make sense of and respond to learner errors and misconceptions. The ontological, epistemological, and axiological aspects of the interpretivist paradigm are discussed below.

4.2.1 Ontological position

Ontology relates to understanding the nature of reality, existence, and being. It explores questions about what exists, how entities exist, and the nature of reality itself (Kivunja & Kuyini, 2017; Makombe, 2017; Saunders et al., 2019). The ontological position of the interpretivist paradigm is that reality is socially constructed and subjective, shaped by individuals' interpretations and experiences. It emphasises the importance of understanding phenomena from the actors' perspective and acknowledging multiple realities rather than a single objective truth (Kivunja & Kuyini, 2017; Makombe, 2017; Saunders et al., 2019; Pervin & Mokhtar, 2022).

In this study, the researcher acknowledged that the realities of ML teachers and their perceptions of learners' misconceptions were socially constructed. These teachers' understanding of errors and misconceptions in Measurement was shaped by their unique experiences, educational backgrounds, and classroom contexts. Therefore, the researcher

recognised that there was no objective reality but multiple interpretations of how teachers perceive and respond to learner errors and misconceptions.

4.2.2 Epistemological position

Epistemology refers to the study of knowledge—including its nature, sources, limits, and validity (Kivunja & Kuyini, 2017; Makombe, 2017; Pulla & Carter, 2018; Saunders et al., 2019; Pervin & Mokhtar, 2022). It examines questions about how knowledge is acquired, justified, and evaluated. Epistemologically, the interpretivist paradigm understands knowledge as situated, subjective, and contextually bound. It emphasises the importance of exploring how knowledge is constructed through social interactions, language, and cultural frameworks. Knowledge is understood to be co-created by researchers and participants rather than discovered independently of human interpretation (Kivunja & Kuyini, 2017; Makombe, 2017; Pulla & Carter, 2018; Saunders et al., 2019; Pervin & Mokhtar, 2022).

In this study, the interpretivist epistemology guided the researcher's exploration of how knowledge about ML teachers' engagement with learner errors and misconceptions was constructed through interactions between teachers, learners, and the educational context. This aligned with understanding teachers' subjective experiences and how they interpreted and made sense of learners' errors and misconceptions in Measurement. Rather than assuming that teachers would provide a single, objective truth about their practices, the researcher recognised that their responses would reflect diverse, context-dependent perspectives shaped by their unique experiences, classroom realities, and professional interpretations. This allowed for a nuanced understanding of how knowledge is constructed and negotiated in real educational settings.

4.2.3 Axiological position

Axiology refers to the study of values, including ethical principles, beliefs, and ideals (Kivunja & Kuyini, 2017; Makombe, 2017; Saunders et al., 2019). It examines questions about what is considered valuable, meaningful, or worthy of pursuit. In research, axiology concerns the values, beliefs, and ethical considerations that guide the research process. The axiological position of the interpretivist paradigm emphasises reflexivity, transparency, and ethical sensitivity in conducting research, acknowledging that a researcher's values and subjectivity shapes the research process and interpretation of data (Kivunja & Kuyini, 2017; Makombe, 2017; Saunders et al., 2019). Thus, interpretivism acknowledges the role of values in research, asserting that researchers' biases and perspectives influence their interpretations (Pretorius,

2024). Axiology emphasises researchers' ethical responsibility to consider the implications of their work for participants and society (Acharya, 2025; Pretorius, 2024).

In this study, the researcher acknowledged that their own values and perspectives inevitably influenced the research process at every stage, from data collection to interpretation. To engage with this, the researcher adopted a reflective stance: as a former teacher of ML, the researcher recognised that their own values—such as a belief in the importance of education and understanding learner needs—shaped their analysis and interpretation of the data. This approach allowed the researcher to explore teachers' values and beliefs about how learners' misconceptions should be addressed, as these values play a critical role in shaping teachers' strategies. In addition, the researcher adhered to ethical considerations by ensuring that the following were upheld: confidentiality, informed consent, and respect for participants' autonomy. The researcher also reflected on their values, biases, and preconceptions that may have influenced the research process, striving for transparency and reflexivity in the researchers' interpretations and reporting. Table 3 summarises the application of the key tenets of interpretivism to this study.

Table 3

Key tenets of interpretivism applied to this study (adapted from Thomas, 2010)

Feature	Description
Purpose of study	To explore the remedial strategies that Mathematical Literacy teachers employ to address learners' errors and misconceptions in Measurement.
Ontology	**Multiple realities exist and are socially constructed.** The researcher recognised that the nature of teaching, learning, and engagement with errors is socially constructed and context-dependent. The researcher acknowledged that teachers' perceptions, beliefs, and experiences shape their engagement practices and that there may be multiple interpretations of what constitutes an error or misconception in mathematical literacy.
Epistemology	**Knowledge is subjective and context-bound.** This guided the researcher in exploring how knowledge about Mathematical Literacy teachers' engagement with learner errors and misconceptions was constructed through interactions between teachers, learners, and the educational context. The researcher sought to understand teachers' perspectives, interpretations, and experiences regarding engagement practices, recognising that these were shaped by their socio-cultural contexts, professional

	backgrounds, and personal beliefs.
Axiology	**Values are inherent in the research process and shape both the production and interpretation of knowledge.** Values influenced the researcher's ethical decisions, such as ensuring participants' confidentiality, informed consent, and respect for their autonomy. The researcher also reflected on their own values, biases, and preconceptions that may have influenced the research process, striving for transparency and reflexivity in their interpretations and reporting.
Design	Case study
Methodology	○ Observation ○ Semi-structured interview ○ Document analysis

Through the interpretivist paradigm, the researcher sought to engage deeply with the complexities of teachers' strategies, creating a systematic and credible study grounded in a consistent set of principles and beliefs. Using the interpretivism paradigm, the researcher aimed to understand and interpret the perspectives of ML teachers as they addressed learners' errors and misconceptions in Measurement. The researcher aimed to use the paradigm to provide clarity in understanding and analysing teachers' approaches to addressing misconceptions, ensuring that the study maintained a clear focus and reliable structure. This supported a disciplined approach to interpreting data and fostered a research process aligned with the established norms and standards within the educational research field.

However, by adopting a paradigm, the researcher also acknowledged certain limitations. The researcher did not aim to impose a single, rigid perspective that might restrict the exploration of alternative viewpoints or novel interpretations. The aim was not to let the paradigm limit the study's scope by excluding valuable insights from other perspectives nor to constrain findings to oversimplify the diversity of teachers' strategies. Rather, the researcher sought a balanced approach that allowed for structured inquiry while remaining open to the complex realities of teaching practices.

The interpretivism paradigm, which emphasises understanding the meaning of human experiences and social contexts, aligns with the qualitative, exploratory approach of the study.

4.3 Research approach

This study adopted a qualitative approach. A qualitative approach focuses on understanding human behaviour, experiences, and social processes within their natural settings, emphasising depth, richness, and context in data collection and analysis (Creswell & Poth, 2016; Maree, 2016; Cohen et al., 2018; Greckhamer & Cilesiz, 2022). This approach allows in-depth exploration of participants' perspectives, experiences, and beliefs, providing rich insights into the nature of misconceptions and the effectiveness of remedial strategies. In this study, a qualitative approach was well-suited to exploring the complex, context-dependent phenomena associated with teachers' remedial strategies for addressing learners' errors and misconceptions in Measurement.

Qualitative methods enable researchers to capture the nuanced meanings and contexts surrounding learners' misconceptions, facilitating a holistic understanding of the phenomenon (Netshakhuma et al, 2024). In this study, a qualitative approach allowed the researcher to gain insight into ML teachers' lived experiences and perspectives as they engaged with learners' errors and misconceptions. Rather than seeking to quantify data or generalise findings, the study aimed to understand the nuanced and subjective ways teachers perceive and address misconceptions in Measurement. A key characteristic of the qualitative approach used in this study was its emphasis on the context and subjectivity of participants. The researcher acknowledged that each teacher's approach to addressing misconceptions was shaped by their unique teaching environment, personal experiences, and professional training.

The qualitative approach allowed these contextual factors to emerge naturally, ensuring that the findings were grounded in the realities of the participants' experiences (Maree, 2016; Greckhamer & Cilesiz, 2022). The qualitative approach was central to addressing the study's objectives and research questions. It facilitated an in-depth exploration of learners' specific misconceptions in Measurement, the strategies teachers used to address them, and the reasons behind their engagement with, or neglect of, certain errors. By focusing on teachers' subjective experiences and perspectives, the qualitative approach provided a rich and nuanced understanding that quantitative methods could not have achieved.

4.4 Research design

The research design used for this study was an exploratory, qualitative case study. According to Creswell and Poth (2016), a case study is a qualitative research design wherein the researcher

uses a thorough data-gathering process to examine one or more current, real-life instances across time. An exploratory, qualitative case study is a research approach that involves an in-depth, context-rich investigation of a single case or a small number of cases to understand complex phenomena, especially when the boundaries between the phenomenon and its context are not clearly defined (Lewis, 2023; Netshakhuma et al, 2024). It is well-suited to exploring complex phenomena in real-world contexts.

In this study, an exploratory case study design was particularly appropriate for examining how Mathematical Literacy teachers address learner errors and misconceptions in Measurement, as it allowed the researcher to focus on specific, contextualised experiences and practices within their natural teaching environments. An exploratory case study design was chosen because it enabled a deep, comprehensive understanding of Grade 12 ML teachers engagement in the Motheo District in the Free State province of South Africa.

This setting provided a defined scope for the study while allowing sufficient depth to explore the phenomenon of interest. The design allowed the researcher to explore teachers' interactions, teaching strategies, and decision-making processes for addressing misconceptions. The exploratory nature of the case study emphasises flexibility, enabling the researcher to adapt to the unique aspects of each teacher's environment and uncover patterns and themes that might not have been apparent with other approaches.

In this study, an exploratory, qualitative case study design was employed to provide an in-depth understanding of how Mathematical Literacy teachers addressed learners' errors and misconceptions in Measurement. The case study served as an illustrative example within a real-world educational context, enabling the researcher to analyse authentic classroom practices, identify challenges, and draw insights from both successes and limitations. This approach allowed for a nuanced exploration of teachers' experiences and strategies, offering rich and contextually grounded data. By using a case study design, the researcher was able to address the study's aim and research questions comprehensively, while also highlighting best practices and lessons that may inform similar teaching contexts.

4.5 Research context, population, and sample

The study was conducted in the Motheo District of the Free State province of South Africa, a region characterised by a diverse population and significant socio-economic challenges (Nkadimeng, 2025). Approximately 90% of the population resides in urban areas, while 10%

lives in rural areas. Poverty levels are high, with unemployment rates reaching 40% in Mangaung, 36% in Mantsopa, and 37% in Naledi. The primary economic activities in the district include the service sector, in urban areas such as Bloemfontein, and agriculture, in rural regions like Mantsopa and Naledi (Marais & Cloete, 2026; Meyer, 2026).

This socio-economic and educational context provided a valuable setting for exploring how Mathematical Literacy teachers address learners' misconceptions in Measurement because learners in such contexts often face resource limitations, uneven learning opportunities, and diverse lived experiences that shape their understanding of mathematical concepts. Teachers working in these settings must frequently adapt their instructional strategies to bridge gaps in foundational knowledge, contextualise abstract concepts, and respond to varied learning needs. These contextual dynamics made the district a rich site for examining how teachers identify and remediate misconceptions in practical, real-world classroom conditions.

The study population consisted of Grade 12 ML teachers at secondary schools across the Motheo District. Although the study focused primarily on the teachers, learners were indirectly involved during classroom observations and the analysis of their work, necessitating their consent for ethical reasons (Flick, 2018). As such learners were informed and provided with an opt-out option. This was done in accordance with Volpe et al.'s (2023) recommendation that best practice in educational research is to inform all learners in a class about the planned classroom observation and, depending on institutional requirements, obtaining consent or at least provide an opt-out option for students or their guardians, especially if any data about the students would be recorded or analysed.

The participating schools included both urban and peri-urban public schools and varied in terms of size, learner enrolment, and resource availability. The schools fell within the national school quintile classification system (Q3 to Q5), with most serving communities characterised by limited socio-economic resources. Enrolment sizes ranged from medium-sized schools with approximately 600 learners to larger institutions with enrolments exceeding 2000 learners. This variation allowed the study to capture teachers' experiences of addressing misconceptions in Measurement across different school contexts within the district.

Convenience and purposive sampling were employed to select schools and participants (teachers). Convenience sampling and purposive sampling are both non-probability sampling techniques: they do not give every member of the population an equal chance of being selected.

Convenience sampling involves selecting participants who are easiest for the researcher to access, such as people who are nearby or readily available, making it quick and cost-effective but prone to bias and limited generalizability (Obilor, 2023; Andrade, 2020). Convenience sampling was used to select schools that were accessible and within proximity, reducing logistical challenges. Six secondary schools offering Grade 12 ML were selected, representing varying performance levels: two schools with poor performance (0%-64%), two with moderate performance (65%-79%), and two with outstanding performance (80%-100%). This approach ensured a broad representation of experiences and perspectives among participating teachers (Douglas, 2022; Das et al., 2022; Lee & Landers, 2022).

The classification of schools according to performance bands (0–64%, 65–79%, and 80–100%) was based on publicly available Department of Basic Education (DBE) and Free State Department of Education (FSDoE) school performance reports, which provide annual summaries of Grade 12 results. These reports were used to identify schools representing a range of performance levels within the district. Selecting schools across these performance bands enabled the study to explore how teachers working in different achievement contexts engage with learner misconceptions in Measurement.

Purposive sampling of teachers ensured that participants met specific criteria relevant to the research questions. Purposive sampling involves deliberately choosing participants based on specific characteristics or criteria relevant to the research question, relying on the researcher's judgment to select those who can provide the most valuable or relevant information (Obilor, 2023; Andrade, 2020). As such, one teacher per school was purposively selected, resulting in six participants. Teachers were chosen based on their current role teaching Grade 12 ML and a minimum of three years of experience teaching the subject—at least two of which had to be consecutive. This specific criterion ensured that the participants had sufficient exposure to and expertise in addressing learners' errors and misconceptions on Measurement.

A profiling questionnaire (Appendix A) was administered to all Mathematical Literacy (ML) teachers at the six selected secondary schools, with approval from the Free State Department of Basic Education (Appendix B). Participation in the profiling process was voluntary, and teachers were informed that the questionnaire was for recruitment purposes only, not for data collection or evaluation. They were given the option to decline participation without any negative consequences.

A total of 18 ML teachers across the six schools were invited to complete the profiling questionnaire. Of these, 16 teachers returned completed questionnaires. The inclusion criteria limited participation to teachers currently teaching Mathematical Literacy in Grade 12 with at least three years of experience teaching the subject. Nine teachers met these criteria. All nine were willing to participate in the study, and six teachers—one from each school—were purposively selected. This selection ensured diversity in terms of school context (urban and rural), teaching experience, and resource environments. In cases where more than one teacher at a school met the criteria, purposive selection was guided by their years of experience, willingness to engage in multiple data collection activities, and availability within the research timeframe.

This recruitment strategy provided a clear and systematic process for identifying relevant participants, ensuring that the selected teachers were well-positioned to offer in-depth insights into the remedial strategies used to address learners' misconceptions in Measurement (Northcote, 2012).

4.6 Data collection

This section outlines the procedures followed to gather the data required to address the research questions of the study. It begins by describing the data collection methods and instruments used to obtain rich, in-depth information from participants. It then explains the piloting process undertaken to refine and ensure the reliability and appropriateness of these instruments within the study context. Finally, it presents the data collection plan, detailing how and when the various methods were implemented to ensure a systematic and ethically sound process.

4.6.1 Data collection methods and instruments

Data collecting techniques are methods for gathering information for research study. They may include field observations, questionnaires, interviews, and document and record analysis (secondary data). These methods can be applied separately or in combination (Myers, 2019). The study employed three qualitative data collection methods—semi-structured interviews, classroom observations, and document analysis—to comprehensively address its research questions and explore teachers' strategies for addressing learners' misconceptions and errors in Measurement. These methods were selected to provide triangulated insights and ensure the reliability and validity of the findings.

The methods used to generate data in this study are summarised in Table 4.

Table 4

Summary of methods used to generate data

Data collection techniques & instruments	Participants/type of document	Rationale	Limitations
Research question (RQ) 1: What are the common misconceptions and errors that learners exhibit in the topic of Measurement in Mathematical Literacy education?			
Semi- Structured interviews (Recorder) Document Analysis (Cell phone-camera)	6 ML Teachers 2 DBE Grade 12 Diagnostic reports 18 Learner's test/exam scripts	To identify common misconceptions & errors in Measurement, providing valuable data on areas of difficulty & misconception	Teachers may experience social desirability bias, favourably presenting themselves and their practices, leading to biased responses. Hence, written work will assist in obtaining richer data.
Research question (RQ) 2: How do Mathematical Literacy teachers engage with learners' misconceptions & errors in Measurement?			
Classroom Observations (Observation schedule) Document Analysis (Cell phone camera)	12 ML teacher observations 12 Learners' exercise books	To identify how teachers provide feedback and engage with learners' misconceptions and errors	The presence of an observer may alter the behaviour of both teachers and learners, leading to a phenomenon known as the observer effect. Hence, learners' books will supplement classroom observation to check previous work.
Research question (RQ) 3: Why do ML teachers engage or not engage with learners' errors and misconceptions?			
Semi-structured interviews	6 ML Teachers	To explore teachers' pedagogical reasons for engaging or not engaging with learner errors and misconceptions	Teachers may experience social desirability bias, favourably presenting themselves and their reasons, leading to biased responses.

4.6.1.1 Semi-structured interviews

Semi-structured interviews were used in this study, using an interview guide (Appendix C) as they offer a conversational yet systematic approach to gain nuanced insights from participants. This method combines structured and unstructured questions, which facilitated an in-depth exploration of the key topics and allowed the researcher to adapt questions based on the flow of conversation and the participant's responses. Adams (2015) and Belina (2022) highlight that this flexibility is particularly helpful in qualitative research for uncovering unexpected insights and understanding complex phenomena, such as teachers' strategies and remediation challenges in ML.

In this study, semi-structured interviews were utilised to address two research sub-questions: 'What are the common misconceptions and errors that learners exhibit in the topic of Measurement in Mathematical Literacy education?' (Sub-question 1) and 'Why do Mathematical Literacy teachers engage or not engage with learners' errors and misconceptions?' (Sub-question 2). These interviews allowed teachers to articulate their observations, experiences, and pedagogical approaches regarding the misconceptions learners displayed. Teachers were encouraged to discuss the nature and frequency of errors learners made in Measurement, reflecting on specific instances to provide rich, qualitative data that illuminated patterns across different contexts.

The interviews also probed teachers' pedagogical choices, delving into their reasons for engaging or not engaging with learners' errors and misconceptions. Maree (2016) attests that a semi-structured interview "allows probing and clarification of answers" (p. 87). As such, this method of inquiry offered insights into teachers' motivations, instructional priorities, and constraints. By structuring the interviews to elicit reflective and detailed responses, the researcher aimed to attain a deep understanding of how and why teachers approached learners' errors the way they did, thereby connecting these practices to broader teaching strategies in ML.

The interviews were conducted with the six teachers at their six schools, capturing diverse perspectives that enriched the dataset. The interviews with ML teachers were conducted in two phases: pre-interviews explore teachers' perspectives on learners' misconceptions in Measurement; post-interviews, following the lesson observations, reflected on classroom strategies. Two visits were made to each school to conduct the pre-interviews and post-interviews.

The instrument used for pre- and post-interviews consisted of four main sections that guided the interview while allowing the researcher adequate flexibility to probe teachers' experiences and perspectives. Section A addressed background information regarding the participants' professional teaching experience in Mathematical Literacy, including years of teaching, grade levels taught, and specific experience with Grade 12 learners. This information was used to contextualise each teacher's responses. Section B focused on identifying common misconceptions and errors observed among learners in the Measurement topic. Teachers were asked to provide concrete examples and to explain how they detect these misconceptions during classroom instruction and assessment.

Section C explored teachers' engagement strategies, including how they respond when misconceptions or errors arise, the specific remedial strategies they employ, and how lesson planning and classroom activities are adapted to address these issues. Section D examined the reasons behind teachers' engagement or non-engagement with learner misconceptions, probing factors such as personal beliefs, teaching philosophy, perceived importance of addressing misconceptions, and contextual barriers like time constraints, resources, and class size.

Pre-observation interviews were conducted prior to classroom observations in order to understand teachers' initial perspectives on learners' misconceptions in Measurement, the strategies they typically used to address these misconceptions, and the contextual challenges they faced in teaching the topic. Post-observation interviews were conducted after the classroom observations to allow teachers to reflect on the lessons observed and to elaborate on the reasoning behind their instructional decisions. Data from both the pre- and post-observation interviews formed part of the thematic analysis presented in Chapters 5–7 and were used to triangulate insights obtained from classroom observations and document analysis.

Each interview lasted approximately 30 minutes to one hour, depending on the depth of the teacher's responses. Using the same structured framework for both interviews ensured consistency in the themes explored while also allowing for a comparison between teachers' initial perspectives and their post-lesson reflections. This approach enabled a rich, layered understanding of how misconceptions were identified and addressed in real classroom contexts.

Semi-structured interviews were used because interviewing teachers individually allowed for a detailed exploration of their unique experiences, strategies, and perceptions, enabling commonalities and differences to be identified in how misconceptions were addressed across

schools. However, this method had a potential limitation: teachers may have felt compelled to present their practices in a favourable light—a phenomenon known as 'social desirability bias'. This could have led to responses that were aligned with perceived norms rather than candid accounts of instructional challenges. To mitigate this limitation, the researcher triangulated the findings using two other methods—lesson observation and document analysis—ensuring a more holistic and reliable data set.

4.6.1.2 Lesson observation

Lesson observation was employed in the study to obtain firsthand insights into teachers' instructional practices and interactions with learners. Observation, as a qualitative method, allows researchers to document naturalistic behaviours and interactions, offering an unfiltered view of phenomena that interviews or focus groups may not capture (Seers, 2012; Smit & Onwuegbuzie, 2018; Umeokafor, 2015; Cohen et al., 2018). In this study, classroom observations were specifically designed to address the second research sub-question: '*how do Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement?*' The researcher observed lessons to understand how teachers identified and addressed learners' errors and misconceptions during instruction.

According to Maree (2016), observation is a routine action in which information is gathered using one's senses and intuition. Hence, observing teacher-learner interactions, instructional strategies, and classroom dynamics, enabled the researcher to gather rich data on how misconceptions in Measurement were handled in real time.

A total of 12 lesson observations were conducted, with two observations conducted per teacher across six schools. One observation proved to be sufficient. However, an additional observation was conducted as the researcher deemed it necessary to deepen their understanding of specific teaching practices. Each observation session lasted one hour—the duration of the lesson.

The researcher utilised an observation schedule (Appendix D) to systematically document key aspects of the lesson, such as the instructional strategies employed, the nature of teacher-learner interactions, and learners' engagement with Measurement concepts. Audio recordings and videos were used to capture classroom discussions and instructional approaches to enhance the richness of the data. However, at one school the teacher and learners indicated that they did not want to be photographed or recorded on video. Their wishes were respected. To ensure that

data collected from this school was comprehensive, detailed field notes were taken during these observations to capture key interactions, instructional strategies, and classroom dynamics.

The Lesson Observation Protocol (Appendix D) consisted of three interconnected sections—A, B, and C—each carefully aligned with the purpose of the study. These sections ensured that the observation process was systematic, comprehensive, and reflective of both contextual and instructional realities within Mathematical Literacy classrooms.

Section A focused on capturing essential observation information to situate each lesson within its appropriate teaching context. This included recording the observer's name, the date of observation, the school and teacher (identified by pseudonym for confidentiality), the grade level, and the specific lesson topic. Collecting these contextual details ensured that each observation was accurately anchored within its setting, allowing the researcher to make meaningful comparisons across schools, teachers, and lesson topics. It also provided a clear audit trail for verifying the consistency and reliability of the data collected during the fieldwork phase.

Section B addressed the main observation criteria and served as the core component of the protocol. It structured the observation around key pedagogical dimensions that guided how teachers engaged with learner misconceptions and errors in Measurement. The researcher examined how learners were arranged in the classroom and whether the seating arrangement supported interaction and participation. Attention was also paid to how the teacher introduced the lesson—whether through revisiting prior concepts or assessing learners' existing knowledge and misconceptions. The observation further explored instances where learner misunderstandings emerged and analysed how teachers identified these misconceptions, for example, through questioning, feedback, or informal assessments. In addition, the researcher observed the specific strategies teachers employed to address misconceptions, such as providing corrective explanations, modelling problem-solving steps, or offering scaffolding support. Learner engagement was another critical area of focus, noting the level of participation, peer interactions, and responsiveness to teacher feedback. The section also considered the instructional strategies adopted, including the use of teaching aids, real-life examples, and differentiation methods. Finally, assessment techniques used during the lesson were noted, especially the presence and immediacy of formative feedback. Collectively, these observation criteria offered a structured lens through which classroom practices could be consistently and systematically examined.

Section C concentrated on post-observation reflection and analytical commentary. After each lesson, the researcher compiled detailed reflective notes that captured the overall quality of the teacher's engagement with learner misconceptions and errors. These reflections included an assessment of the teacher's strengths, areas requiring improvement, and noteworthy classroom incidents or interactions. The reflective process also allowed the researcher to identify emerging patterns across different observations and determine aspects that warranted further exploration in subsequent lessons. In doing so, the section facilitated deeper interpretation beyond surface-level description, contributing to a richer understanding of instructional practices in Mathematical Literacy.

Taken together, these three sections ensured a rigorous and consistent approach to analysing learner artefacts. This approach allowed the researcher to capture variations in teaching practices and classroom dynamics, ensuring that the data reflected a range of instructional strategies and learner behaviours. While classroom observations provided valuable insights, the researcher was mindful of the potential observer effect. Teachers and learners may have modified their behaviours due to the presence of an observer, potentially affecting the authenticity of the data. Recognising this limitation, the researcher used triangulation by incorporating data from semi-structured interviews and document analysis to corroborate findings, thereby enhancing the study's trustworthiness.

4.6.1.3 Document analysis

Document analysis was used as a third data collection method, enabling the researcher to systematically examine and interpret existing records and texts to derive insights relevant to the research objectives. Document analysis was employed to address the first and second research sub-questions: 'What are the common misconceptions and errors that learners exhibit in the topic of Measurement in Mathematical Literacy education?' and 'How do Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement?'.

Maree (2016) explains that when using text or document reviews to collect data, the researcher concentrates on printed communications that offer explanations and justifications for the phenomenon under study. This method provides authentic data from real-world contexts, complementing the other qualitative methods (Kutsyuruba, 2023; Morgan, 2022). In this study, by analysing instructional materials, samples of learners' work, and diagnostic reports, the researcher aimed to gain an understanding of learners' misconceptions and how teachers responded to them.

The researcher analysed 18 learner scripts—three from each of the six schools—categorised into three performance levels: low (0-49%), average (50-69%), and high (70% and above) as a selection criterion. This criterion allowed the researcher to capture various learner experiences and errors across different achievement levels. Furthermore, 12 learner exercise books (two from each school) were analysed to explore teacher feedback and instructional strategies for addressing misconceptions.

The researcher analysed two DBE diagnostic reports (2022 and 2023) to complement the data collected from interviews and classroom observations. These reports were selected because all participating teachers had taught Mathematical Literacy during both of these years, meaning that the diagnostic reports reflected the same curriculum content and learner cohorts relevant to their teaching context. By analysing reports corresponding to the years in which the interviewees were actively teaching, the researcher ensured that the findings were directly connected to the instructional realities and challenges the teachers faced in their classrooms.

Comparing the two reports allowed the researcher to identify recurring trends and patterns in learners' errors and misconceptions in Measurement over time. This provided a broader contextual understanding of the persistent challenges that teachers were likely to encounter, thereby enriching and grounding the interpretation of their interview responses and classroom practices.

A protocol was developed to analyse the documents (Appendix E). The document analysis protocol contained three sections designed to guide the process from basic identification to deeper interpretation and reflection. Section A focused on capturing essential identification information. This included details such as the name of the school, the teacher, and the specific type of document being analysed—whether a test script, assignment, investigation script, exam script, or a diagnostic report. Gathering this contextual information ensured that each document was accurately situated within its learning environment, enabling more meaningful comparisons across different schools and assessment types.

Section B addressed the analysis criteria and formed the core of the protocol. It guided the systematic examination of several key elements: the content covered in the document and its alignment with the Mathematical Literacy curriculum; the common misconceptions and errors identified; and the observable patterns or trends in how these misconceptions manifested. Errors and misconceptions were categorised into computational, procedural, and conceptual

types to allow for more precise analysis. This section also examined the nature of teacher feedback, the level of detail provided, and any strategies or remedial actions documented to address learners' difficulties. In addition, it considered overall learner performance and the specific areas where learners appeared to struggle most.

Section C prompted reflection on the findings derived from the analysis. This section focused on interpreting the broader implications of the identified misconceptions and errors for teaching and learning in Measurement. It encouraged consideration of possible underlying causes—such as instructional methods, curriculum design, or learner background—and the formulation of targeted suggestions for improving instructional strategies. By integrating reflection into the protocol, the researcher was able to move beyond merely describing learner errors to understanding their significance and potential impact on classroom practice.

While document analysis enabled valuable insights to be gleaned into the nature of learner misconceptions and the instructional approaches teachers employed to address them, the use of this method alone might have lacked the contextual depth necessary for fully understanding the reasons behind certain errors or instructional strategies. The researcher used document analysis in combination with interviews and classroom observations to address this limitation, ensuring a robust and comprehensive data analysis.

4.6.2 Piloting data collection instruments

A pilot study is a small preliminary exploration designed to test the feasibility of a larger research project (Kunselman, 2024; Gudmundsdottir & Brock-Utne, 2010; Sánchez-Ferrer et al., 2024). A pilot study is useful for refining research methods and ensuring the reliability and validity of data collection instruments before the main study is conducted (Malmqvist et al., 2019). A pilot study can serve various purposes, including assessing operational feasibility, evaluating potential efficacy, and determining the generalizability of results (Kunselman, 2024; Gudmundsdottir & Brock-Utne, 2010; Sánchez-Ferrer et al., 2024).

In this study, a pilot study was conducted to refine the research instruments and assess the feasibility of the main study, ensuring methodological rigour and the reliability of the data collection process. This small-scale exploration involved two ML teachers who met the inclusion criteria but were not part of the main study.

The pilot focused on testing the semi-structured interview questions, classroom observation schedule, and document analysis protocol. During the pilot, the semi-structured interview

questions were evaluated for clarity and relevance in eliciting detailed responses about learners' misconceptions and teachers' strategies for addressing errors in Measurement. The pilot interviews revealed some ambiguities in the phrasing of certain questions, which were reworded to ensure participants could provide comprehensive answers. For example, questions about the types and frequency of learner errors were clarified to prompt more specific and reflective responses.

The classroom observation schedule was tested by observing one lesson per teacher, focusing on how they addressed learners' misconceptions during Measurement lessons. These observations highlighted the need to refine categories for documenting learners' engagement and teaching interventions.

The document analysis framework was piloted using a sample of three learners' exam scripts and three learners' exercise books. This enabled the researcher to identify gaps, such as the need to include specific categories for types of errors and teacher feedback on Measurement tasks. These insights informed revisions to ensure the framework captured relevant data comprehensively in the main study.

The pilot also helped the researcher test recording methods, resulting in more discreet techniques to capture classroom dynamics without disrupting the natural flow of lessons. The pilot study proved invaluable for identifying and resolving potential issues with the research instruments, enhancing their effectiveness and alignment with the study's objectives. This preparatory phase ensured that the main study proceeded with robust tools capable of yielding reliable and valid data, contributing significantly to the study's overall success.

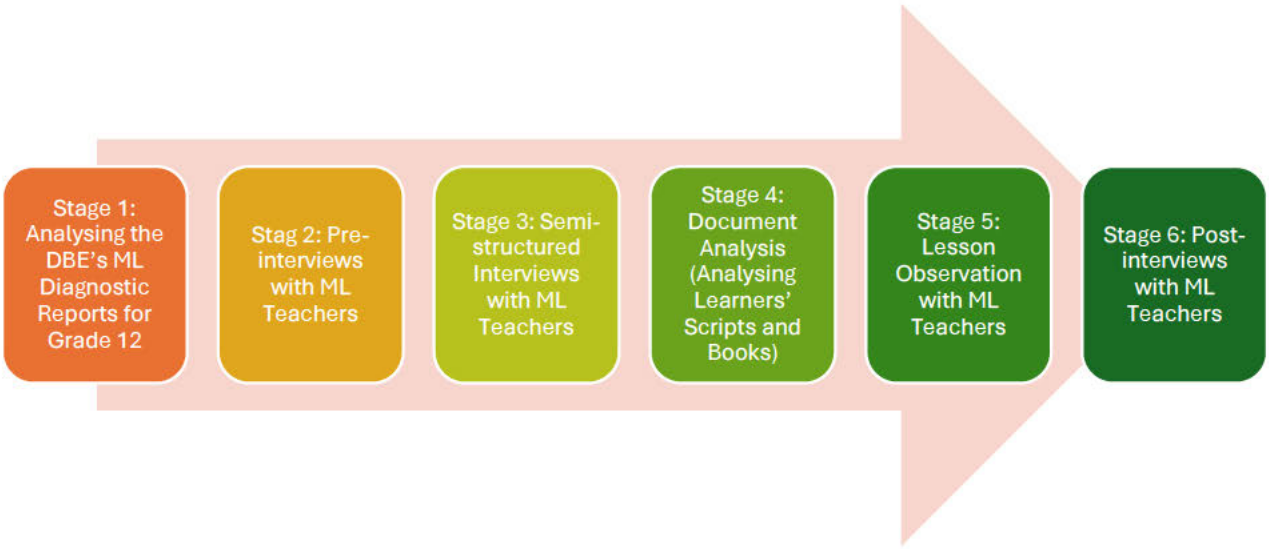
4.6.3 Data collection plan

Data collection spanned six weeks. It involved 12 visits to the participating schools to conduct interviews, document analysis, and lesson observations. Each stage was meticulously planned to minimise disruption to school activities while ensuring robust data collection and to ensure the research addressed the key research questions and effectively captured the participants' perspectives.

A six-stage plan was developed for data collection, as represented in Figure 4.

Figure 4

Order of data generation for the study



Stage 1: Analysing the DBE's ML Diagnostic Reports

The first data generation stage focused on analysing the two DBE's diagnostic reports. These reports provided valuable insights into common learner errors and misconceptions about Measurement in ML. The analysis identified recurring trends and areas where learners struggled, which informed the development of targeted educational programs and interventions. This stage set the foundation for the research, providing a contextual understanding of the issues the teachers were addressing in their classrooms. After reviewing the diagnostic report, the researcher had a deeper understanding of learners' specific challenges in Measurement.

Stage 2: Pre-interviews with ML Teachers

The second stage involved conducting pre-interviews with ML teachers. These preliminary meetings helped familiarise the researcher with the teachers and provided a platform for discussing their perceptions of learners' errors and misconceptions in Measurement. During this stage, the researcher also sought to understand teachers' strategies to address learners' misconceptions.

Stage 3: Semi-structured interviews with ML teachers

Following the pre-interviews, the researcher conducted semi-structured interviews with the participating ML teachers. These interviews aimed to delve deeper into the teachers' understanding of learners' errors and misconceptions in Measurement and explore why participants did or did not engage with these issues in the classroom. The interviews were designed to address specific sub-research questions (1 and 3) to ensure that the data collected would directly respond to the study's objectives.

Stage 4: Document analysis: Analysing of learners' classroom work and assessments

After the interviews, the researcher proceeded with document analysis, focusing on analysing learners' exam scripts and workbooks. A selection of 18 June exam scripts (three from each of the six schools) were collected for analysis. The researcher also reviewed 12 learners' exercise books (two from each school) to understand how learners approached Measurement tasks and where they made common errors. The document analysis aligned with sub-research questions 1 and 3 and aimed to identify patterns in learners' errors and misconceptions.

Stage 5: Lesson observation

Following the document analysis, the researcher observed each participating teacher in the classroom on two separate occasions. These observations allowed the researcher to witness firsthand how teachers engaged with learners' errors and misconceptions in real time. The observations focused on understanding teachers' instructional strategies and approaches to address and correct common learner mistakes. By observing the classroom dynamics, the researcher gained a deeper understanding of how theory translated into practice, offering insights into the effectiveness of different teaching methods in mitigating misconceptions.

Stage 6: Post-interviews with participants

The final stage of data collection involved post-interviews with the participating ML teachers. These interviews took place after the lesson observations and allowed teachers to reflect on their teaching practices. Teachers were asked to elaborate on when and why they chose to address specific errors or misconceptions. This stage allowed for a deeper exploration of teachers' reflections on their classroom strategies and provided an opportunity to gain insights into how their experiences shaped their teaching approaches.

4.7 Data analysis and presentation

Data analysis involves systematically inspecting, cleaning, transforming, classifying, and modelling data to extract meaningful insights and support decision-making (Bhatta & Bhatta, 2013). In this study, data analysis was an iterative and reflective process designed to uncover the meanings teachers attached to their strategies and practices for addressing learners errors and misconceptions in Measurement. This process is key to structuring findings, understanding complex patterns, and contextualising teachers' experiences and practices (Alem, 2020).

To analyse the data gathered from semi-structured interviews, observations, and document analysis, the study employed thematic analysis, a widely recognised qualitative method that is both flexible and accessible (Vaismoradi et al., 2013). Thematic analysis enabled the researcher to identify and interpret patterns, themes, and meanings in the data, which were then synthesised to address the study's objectives. The rigorous and systematic nature of this method ensured that the analysis was trustworthy and methodologically sound (Nowell et al., 2017).

The thematic analysis of data in this study followed the six-step schema proposed by Braun and Clarke (2006), which provided a structured framework:

1. **Familiarisation with the data**: The researcher immersed herself in the data by repeatedly reading interview transcripts, observation notes, and document analysis summaries to gain a comprehensive understanding. This step was crucial for identifying preliminary ideas and ensuring the researcher was well-acquainted with the content.

2. **Generating initial codes**: Data were systematically coded to capture significant features relevant to teachers addressing misconceptions in Measurement. Codes were manually applied to text excerpts reflecting recurring ideas, behaviours, or practices aligned with the study's objectives.

3. **Searching for themes**: The codes were analysed to identify overarching themes. For example, themes such as 'teacher-led correction strategies' and 'contextual influences on misconceptions' emerged as recurring patterns in the data.

4. **Reviewing themes**: The themes were reviewed for coherence and relevance to the research questions. Data excerpts were revisited to ensure alignment between themes and the underlying data, refining categories as needed.

5. **Defining and naming themes**: Each theme was assigned a clear definition to articulate its meaning and relevance. Themes were named in a way that captured their essence.

   Table 4 below provides an example of how raw data excerpts were coded and developed into themes.

Table 5

Coding and theme development

Data excerpt	Initial code	Category	Theme
"Before we start the new topic, I go back to what they did in Grade 10 because they forgot how to convert units."	Revisiting prior learning	Activation of prior knowledge	Lesson introduction and activation of prior knowledge
"I draw the shape on the board and ask learners to come measure it themselves."	Hands-on demonstration	Visual and practical teaching strategies	Teacher remedial strategies
"Some learners think area and perimeter are the same thing, so I make them compare both calculations."	Addressing conceptual confusion	Identification of misconceptions	Identification of misconceptions

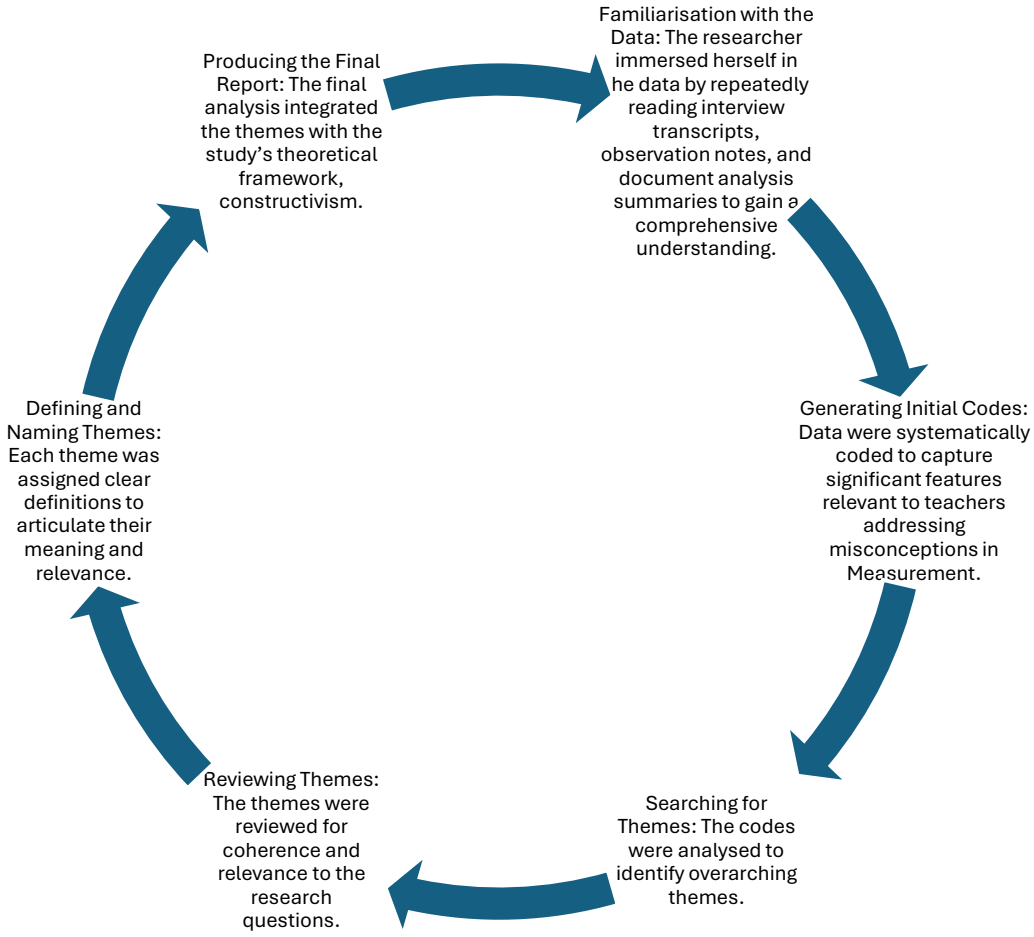
   Through this iterative process, similar codes were grouped to form categories, and categories were further refined into broader themes that addressed the research questions.

6. **Producing the final report**: The final stage of analysis integrated the themes with the theoretical framework—constructivism. Findings were contextualised within the framework to examine how teachers' practices aligned with the principles of active learning, scaffolding, and learner-centred instruction. The integration of the theoretical framework deepened the analysis, providing a conceptual lens to explore how teachers' engagement with learners' errors and misconceptions reflected or diverged from theoretical principles. This approach ensured the thematic analysis was theoretically informed, enabling the study to offer rich and grounded insights. The discussion and conclusion sections further reflected on these findings in relation to the theoretical

framework, advancing understanding of the interplay between theory and practice. Combining thematic analysis and constructivism enhanced the study's ability to interpret data while remaining conceptually grounded. This synergy ensured the analysis was methodologically rigorous and theoretically insightful, addressing the research questions comprehensively. Figure 5 models the six steps of thematic analysis conducted in the study.

Figure 5

Braun and Clarke (2006) Thematic analysis of data



Conflicting or divergent observations were addressed through triangulation across data sources. For example, teachers' explanations during interviews were compared with classroom observations and documentary evidence from learners' work. In cases where teachers reported strategies that were not consistently observed in practice, these discrepancies were treated as analytically meaningful rather than errors. Such differences were interpreted as reflections of

contextual constraints, such as time pressure or class size, which influenced teachers' ability to implement certain strategies.

The interpretation of themes was guided by the principles of constructivist theory. Constructivism emphasises that learning occurs through interaction, reflection, and the reconstruction of prior knowledge (Piaget, 1977; Vygotsky, 1978). Consequently, during analysis particular attention was given to evidence of scaffolding, learner interaction, activation of prior knowledge, and opportunities for conceptual reconstruction. These constructivist principles helped frame the interpretation of how teachers identified and addressed learners' misconceptions in Measurement.

4.8 Quality assurance: Trustworthiness

Trustworthiness in research, especially in qualitative studies, refers to the overall quality, rigor, and believability of the research findings (Korstjens & Moser, 2018; Thomas & Magilvy, 2011). According to Korstjens and Moser (2018), credibility, confirmability, reliability, and transferability are four vital elements of assuring the overall quality of qualitative research. These elements help to establish that the findings are accurate and also applicable and consistent across various contexts (Thomas & Magilvy, 2011). This section outlines how the researcher ensured the trustworthiness of this study.

4.8.1 Credibility

Credibility in qualitative research refers to the extent to which the researcher's interpretations and conclusions accurately reflect the participants' perspectives. To enhance the credibility of the study, the researcher employed triangulation, member checking, and peer debriefing, as recommended by Johnson et al. (2020), Maree (2016), and Tracy (2013). Triangulation strengthened the findings by drawing on multiple data sources, methods, and perspectives. This study collected data through semi-structured interviews, classroom observations, and document analysis, which provided a comprehensive understanding of teachers' strategies to address learners' misconceptions in Measurement. By incorporating diverse data sources, the researcher ensured the findings were well-supported and credible.

Additionally, member checking was implemented by sharing the researcher's interpretations and preliminary findings with the participants. This allowed them to review and validate the accuracy of the researcher's conclusions, thereby enhancing the credibility of the study.

Participants were encouraged to offer feedback or correct any misunderstandings, confirming the findings' trustworthiness.

4.8.2 Transferability

Transferability, on the other hand, refers to the extent to which the findings of a qualitative study can be applied to other contexts or populations. To ensure transferability, the researcher provided thick descriptions of the research setting, the participants, and the data collection process. This approach, as advocated by Korstjens and Moser (2018) and Lincoln and Guba (1985), allows readers to assess the relevance of the findings to different educational environments. The researcher thoroughly described the study's context, including the demographic and socio-economic characteristics of the teachers, the specific strategies they employed, and the challenges they faced when engaging with learners' errors in Measurement. By offering a detailed account of the study context and design, the researcher enabled readers to determine the applicability of the findings to other settings or groups of teachers.

4.8.3 Dependability

Dependability in qualitative research refers to the consistency and reliability of the research process (Ahmed, 2024). To enhance dependability, the researcher employed an audit trail that recorded the research process, including decisions made during data collection and analysis. Lincoln and Guba (1985) argue that an audit trail supports dependability as it enables others to verify the research process. In this study, the researcher maintained a detailed record of all decisions made throughout the study, including sampling, data collection methods, and analytical processes. This record also included meeting notes, data reflections, and emerging findings.

4.8.4 Confirmability

Confirmability is a critical aspect of trustworthiness that ensures that a study's findings are derived from the data and not from the researcher's biases or preconceived notions. To ensure confirmability, the researcher utilised reflexivity—a strategy for examining how the researcher's background, experiences, and assumptions might influence the study. As Lincoln and Guba (1985) and Tracy (2010) explain, reflexivity allows the researcher to maintain objectivity and avoid bias. In this study, the researcher kept a reflective diary throughout the research process to record thoughts, decisions, and insights related to the study's methods and findings. This process helped the researcher remain aware of how their personal biases could shape their interpretation of the data.

Additionally, the researcher provided a transparent account of the methods and procedures used in the study to ensure that readers could follow the reasoning informing the decisions that were made. By documenting these processes, the researcher could demonstrate the confirmability of the study's findings, showing that they were rooted in the data rather than subjective interpretations.

Employing strategies such as triangulation, member checking, audit trails, and reflexivity thus ensured this study's trustworthiness, strengthening the findings and providing a robust framework for understanding the strategies used by participating ML teachers to address learners' misconceptions and errors in Measurement.

4.9 Methodological considerations

This study employed an exploratory qualitative case study design involving six teachers from six schools. The purpose of the study was to examine how Mathematical Literacy teachers engage with learners' misconceptions and errors in the topic of Measurement in Grade 12. The case study design allowed for detailed investigation of classroom practices and teachers' experiences within their natural teaching environments.

In order to accommodate participants' preferences and availability, the researcher provided flexibility regarding the mode and location of interviews. While most participants chose in-person interviews conducted at their schools, some opted for online interviews due to scheduling constraints. Allowing participants to select a convenient interview environment helped ensure their comfort and willingness to participate. However, the researcher did not control the physical settings in which the online interviews took place, which meant that some environmental factors could not be standardised.

Despite this variation, all interviews followed the same semi-structured interview protocol and were conducted in a consistent manner to maintain the integrity of the data collection process. This ensured that discussions remained focused on the teachers' strategies for identifying and addressing learners' misconceptions in Measurement.

4.10 Ethical issues

Ethical considerations played a crucial role in this qualitative research, particularly given the involvement of human participants (Maldonado-Castellanos & Barrios, 2023). These considerations are foundational to ensuring that the research process is conducted with respect

for the participants' rights, including their right to self-determination, privacy, and freedom from harm. Ethical research practices are guided by international regulations and guidelines, which provide a structured framework for ensuring that studies are conducted with integrity and accountability. Central to these ethical standards are informed consent and confidentiality practices, which are essential to protect participants and ensure that their participation is voluntary and informed (Yip et al., 2016).

In alignment with these ethical principles, the researcher undertook several key actions to ensure that the study adhered to ethical standards. First, the researcher sought approval from relevant authorities before collecting data. This began with obtaining permission from gatekeepers. First, the researcher approached the provincial education authority—the Free State Department of Education—which provided a letter that served as formal authorisation for the researcher to contact schools within the province (Appendix B). This was necessary to ensure that the study followed local educational policies and protocols for engaging with schools and their staff for the purpose of research.

Next, the researcher sought permission from selected school principals (Appendix F). The letters of permission received from the schools (Appendix G) allowed the researcher to access the schools and meet with the ML teachers who were the focus of the study. The principals' approval was essential to ensure that the research was conducted following school regulations and that the teachers were informed and supportive of the research.

Once permission from gatekeepers and school principals was secured, the researcher sought ethical approval from the Humanities and Social Sciences Research Ethics Committee (HSSREC) at the University of KwaZulu-Natal. Approval was granted (HSSREC-00026818) (Appendix H). This formal approval process was required to ensure that the study met the ethical guidelines established by the institution.

Upon visiting the schools and meeting with the principals, the researcher was referred to the Heads of Departments (HoDs) for Mathematics. The HoDs played a pivotal role in facilitating the study by identifying and allocating the relevant teachers for participation. During these initial meetings, the researcher briefed the HoDs and the selected teachers about the study's purpose, scope, and methodology.

A key aspect of the ethics process involved obtaining informed consent from the participants. The researcher prioritised providing the participants with clear, detailed information about the

study's purpose, procedures, and potential impacts. Participants were given a form with this information (Appendix I) and provided their written consent. This step was essential to ensure that the teachers understood their rights and were fully aware of what their participation would entail. This included explaining the voluntary nature of participation and the right of participants to withdraw at any point without consequence. Informed consent was obtained before any data was collected.

Confidentiality was also of utmost importance throughout the research process. Personal identifiers were removed from the data and replaced with pseudonyms to protect participants' identities. All information shared by participants was handled with strict confidentiality. This approach aimed to create a safe environment where participants could express themselves freely, knowing their contributions would not be linked to them personally.

Furthermore, the researcher was conscious of the potential impact the research might have on the participants and the schools. In designing the study, efforts were made to minimise any risks or harm associated with participation. The researcher ensured that the study was designed to be as unintrusive as possible, respecting the teachers' time and professional obligations. Additionally, the study aimed to maximise benefits to the participants and their schools by sharing insights into the strategies that the participating teachers employed to address learners' misconceptions in teaching Measurement. By contributing to the body of knowledge on this topic, the research has the potential to benefit both teachers and learners, offering practical strategies that could improve teaching practices and learning outcomes.

4.11 Chapter summary

This chapter has presented the methodology used to conduct this study. The research paradigm that guided the study, the research approach, the research style, and data collection and analysis methods were discussed. The study context and sample were presented. The chapter concluded with a discussion of quality considerations, limitations, and ethical considerations.

The next chapter presents the findings related to the first research objective: 'identify the common misconceptions and errors that learners exhibit in Measurement in Mathematical Literacy'.

CHAPTER 5: FINDINGS ON LEARNERS' COMMON ERRORS AND MISCONCEPTIONS IN MEASUREMENT

5.1 Introduction

The previous chapter described the methodology used in this study. This chapter, along with the following two chapters, presents the findings of the study aligned with the three research sub-questions, as follows:

> Chapter 5: Common misconceptions and errors that learners exhibit in Measurement in Mathematical Literacy (Research sub-question 1)
> Chapter 6: How Mathematical Literacy teachers engage with learners' misconceptions and errors in Measurement (Research sub-question 2)
> Chapter 7: Why Mathematical Literacy teachers engage, or do not engage, with learners' errors and misconceptions in Measurement (Research sub-question 3)

The findings are informed by themes identified in the literature review and supported by evidence from diagnostic reports, learners' exam scripts, and interviews with teachers.

This chapter presents an overview of the relevant characteristics of the participants. The findings derived from DBE diagnostic reports, teacher interviews, and samples of learners' scripts that respond to Research sub-question 1 are presented.

5.2 Characteristics of participants

Table 5 presents a summary of the professional attributes of the six teachers who participated in this study.

To ensure confidentiality, each participant was assigned a pseudonym: Ms Zyphron, Mr Vexora, Ms Tarkis, Mr Orvex, Ms Luneth, and Mr Quenric. These pseudonyms were used consistently throughout the study to protect the identity of the participants.

Table 6

Characteristics of participants

Pseudonym	Years of Teaching Experience	Other Subjects Taught	Years of Teaching ML in Grade 12	Highest Qualification	ML Training Workshops Attended
Ms Zyphron	10	Life Orientation	4	Bachelor of Education	Yes

Mr Vexora	15	Technical Mathematics	8	Postgraduate Diploma in Education	Yes
Ms Tarkis	8	Business Studies	3	Bachelor of Education	No
Mr Orvex	12	Geography	5	Master of Education	Yes
Ms Luneth	9	Mathematics	6	Honours in Education	Yes
Mr Quenric	7	None	3	Bachelor of Education	No

The participants' years of teaching experience varied, contributing to a rich and diverse perspective on teaching ML. All six participants were experienced teachers with at least five years of teaching experience who had taught Grade 12 ML for a minimum of two consecutive years at the time of the study.

In addition to ML, some participants taught other subjects, such as Life Orientation and Technical Mathematics (TM), which provided valuable insights into how cross-disciplinary teaching influences ML remediation strategies. Regarding qualifications, all participants held at least a bachelor's degree, with some having attained postgraduate qualifications in education or related fields.

Specific ML training was a key area of interest. The participants reported attending various ML-focused professional development workshops and training sessions to enhance their instructional strategies. However, none of the participants held certifications specifically related to ML, highlighting a gap in specialised training among the teachers.

5.3 Development of themes and categories

The four categories of misconceptions and errors used were identified in the literature (Andriani & Nurhasanah, 2021; Booth et al., 2017; Ndemo & Ndemo, 2018; Morales Brignac, 2022; Rashid et al., 2021; Guerra-Reyes et al., 2024; Majeed et al., 2023; Ili, 2022; Sanina & Sokolov, 2021; Roell et al., 2019; Abakah & Brijlall, 2024; Fardah & Palupi, 2023;Wardah et al., 2021; Bansilal & Debba, 2012) as a basis for analysing both primary and secondary data. I then analysed the secondary data collected from two Department of Basic Education (DBE) diagnostic reports and the primary data collected from learners' exam scripts and interviews with participating teachers.

The themes derived were compared from the data with the themes derived from the literature. Table 6, below, presents the themes derived from the literature matched with those from diagnostic reports, learners' scripts and teacher interviews. The findings from the primary and secondary data reveal significant similarities with the constructs identified in the literature on errors and misconceptions. However, a few new themes emerged from the data, as presented in the third column.

Table 7

Comparison of literature-based themes with the results of collected data

Themes derived from the literature (cf. Chapter 2)	Results of analysis of primary and secondary data	New emergent themes from data
Procedural Errors and Misconceptions in Measurement		
Procedural errors in Measurement (Andriani & Nurhasanah, 2021)	○ Inaccurate rewriting of problems ○ Inefficiencies in calculations ○ Lack of thoroughness in calculations ○ Forgetting essential steps ○ Incomplete answers or unanswered questions ○ Misuse of symbols ○ Misapplication of formulas ○ Limited understanding of mathematical concepts ○ Flawed understanding of mathematical procedures	**Integration of multiple skills and concepts**
Procedural Misconceptions in Measurement (Booth et al., 2017; Ndemo & Ndemo, 2018)		**Integrated practical measurement tasks, such as map reading and real-world calculations**
Common Computation Errors and Misconceptions in Measurement		
Computation Errors in Measurement (Morales	○ Misunderstandings of unit conversion	**Dual-layered error:** **Calculator-induced procedural blindness**

Brignac, 2022; Rashid et al., 2021) **Computational Misconception in Measurement (Guerra-Reyes et al., 2024; Majeed et al., 2023; Ili, 2022)**	○ Incorrect application of formulas and basic arithmetic errors ○ Forgetting conversion factors ○ Thinking radius and diameter (units) are the same ○ Lack of understanding of unit relationships ○ Believing that map measurements and ruler measurements are the same ○ Confusing area with perimeter formulae ○ Using terms interchangeably despite their distinct mathematical properties	○ **Cascading Computational Errors in Scale Application** ○ **Unit Dissociation and Symbolic Detachment** ○ **Unit Neglect and the Breakdown of Comparative Reasoning** ○ **Failure to Cross-Check Computational Results with External References**
Conceptual errors and misconception in Measurement **Conceptual errors in Measurement (Sanina & Sokolov, 2021; Roell et al., 2019)** **Conceptual misconception in Measurement (Abakah & Brijlall, 2024; Fardah & Palupi, 2023)**	○ Applying whole number rules to decimals, misinterpreting fractions/decimals, especially with time ○ Inability to convert problems into mathematical models ○ Insufficient knowledge of problem-solving steps ○ Inability to round up or down ○ Misunderstanding fundamental mathematical literacy concepts ○ Misconceptions about definitions	**Importance of contextualisation of concepts in measurement tasks** **Intersection of Measurement and proportional reasoning**
Interpretation and application errors and misconceptions in Measurement (Wardah et al., 2021; Bansilal & Debba, 2012)	○ Incorrectly extracting & interpretating data ○ Errors solving real situations, such as simplification, validation or verification. ○ Errors solving mathematics word problems, including inconsistencies in interpreting problem sentences	**Dual challenge: Contextualising measurement tasks and application to formulae**

	○ Lack of understanding of the problem or formula ○ Incorrectly checking answers	

Through the comparison of findings from the literature, document analysis and interviews, as presented in Table 6, the researcher identified four key themes, each with two categories, which encapsulate the common misconceptions and errors learners exhibited, or were reported to exhibit, in the topic of Measurement in ML. These were procedural challenges, computational challenges, conceptual challenges, and interpretation and application challenges, as shown in Table 8.

Table 8

Themes and categories emanating from data relating to Research sub-question 1

LEARNERS' COMMON MISCONCEPTIONS & ERRORS IN MEASUREMENT	
Theme 1: Procedural Challenges	
Category 1	Procedural Errors
Category 2	Procedural Misconceptions
Theme 2: Computational Challenges	
Category 1	Computational Errors
Category 2	Computational Misconceptions
Theme 3: Conceptual Challenges	
Category 1	Conceptual Errors
Category 2	Conceptual Misconceptions
Theme 4: Interpretation and Application Challenges	
Category 1	Interpretation Errors
Category 2	Application Errors

Each theme provided a framework for understanding the specific nature of the common errors and misconceptions learners exhibit.

5.4 Theme 1: Procedural challenges in Measurement

Procedural errors refer to mistakes that occur when an individual incorrectly applies, omits, or misinterprets a step in a recognised algorithm or method during the problem-solving process. Such errors typically reflect misunderstandings of the correct sequence or logic of procedures, rather than failures in arithmetic accuracy (Dorner et al., 2025; Delastri & Lolang, 2023). They may arise from inadequate conceptual understanding of the steps required to solve a problem or from confusion about when and how to apply a particular rule or method. This section presents procedural errors and misconceptions as subsections of procedural challenges in measurement.

5.4.1 Procedural errors in Measurement

Procedural errors were among the most frequent and persistent difficulties identified in the study. These errors manifest as syntactical or algorithmic mistakes and often involve the misapplication of mathematical procedures (Andriani & Nurhasanah, 2021; Guce, 2017; Baharuddin et al., 2021). In this study, procedural errors in Measurement were prevalent among learners and manifested in various forms, including misapplication of formulas, incorrect calculations, and misunderstanding of mathematical concepts. These errors were found consistently across the different data sources, which included diagnostic reports, teacher interviews, and a sample of learners' exam scripts.

The DBE's 2022 diagnostic report documents several instances of learners incorrectly performing standard measurement procedures. For example:

> *Some candidates divided by 60 instead of multiplying to convert hours to minutes (DBE, 2022; p. 191(e)). Many candidates multiplied the sides instead of adding them to calculate perimeter. Some candidates omitted the bracket, resulting in the common error: Perimeter = 2 × 239 + 89 mm instead of Perimeter = 2 × (239 + 89) mm. Some candidates gave the answer as a square unit (DBE, 2022; p. 192(a)). Candidates could not change the subject of the formula. Most candidates did not round the final answer to the nearest gram (DBE, 2022; p. 193(d)). Instead of dividing by 10 and 14, most candidates multiplied. They failed to apply the ratio to calculate the number of litres required, given the spread rate (DBE, 2022; p. 194(d)).*

Such errors are not isolated miscalculations but demonstrate confusion about the sequence and logic of procedural operations. The reversal of multiplication and division during unit

conversions suggests that learners often apply memorised steps without understanding the conceptual rationale for those operations. Likewise, omitting brackets and giving answers in square units indicates a failure to internalise the connection between symbolic notation and geometric meaning.

The following year's DBE (2023) report corroborates this pattern, highlighting similar procedural breakdowns:

> *Candidates did not follow instructions, and instead of writing down the letter, they wrote the definition (DBE, 2023; p. 205(a)). Candidates did not read the whole extract and only worked with the drawn diagrams. Most candidates used the dimensions of the post cap rather than the posts. Candidates failed to link the question from previous and related sub questions (DBE, 2023; p. 208(f)). Some candidates added the areas of the triangle and the rectangle but did not multiply by 4 and 12 to get the total area of the caps that needed to be painted. Some candidates used the length of the floor runway, which was 54, instead of the given width of 4 feet, which was in the context (DBE, 2023; p. 208(g)).*

These findings suggest that procedural errors occur not only in numeric computation but also in learners' inability to follow logical sequences across related questions. This implies fragmented procedural knowledge, as learners can carry out discrete steps but struggle to connect them into coherent solution strategies, a hallmark of surface learning rather than integrated conceptual understanding.

Interviews with teachers reinforced these findings and provided qualitative depth to the documentary data.

For example, Mr Quenric reported:

> *"They mix up the formulas—like, for volume or surface area. And I can't always catch their mistakes in time: especially in class, because I'm also working through it with them."*

Ms Luneth stated:

> "*A frequent error I see is learners incorrectly applying formulas. For example, when calculating the volume of a cylinder, they sometimes mix up the formula with surface area or forget to square the radius."*

Ms Tarkis reported:

> *"Learners don't know terminologies, which makes it difficult to interpret questions. Learners struggle with conversions. Learners struggle to change the subject of the formula, for example, if they are given $V = L \times W \times H$ and they are asked to calculate H."*

Mr Orvex said*:*

> *"One error I often see is in applying the formula for the circumference of a circle. Learners sometimes confuse the formula for the area $A = \pi r^2$ with the circumference $C = 2\pi r$, especially under exam pressure."*

Mr Vexora reported:

> "*Learners are struggling to calculate perimeter and volume and integrate measurement with other topics."*

Collectively, these testimonies show that the teachers viewed procedural errors as symptomatic of cognitive overload, where learners recall formulas but lack the metacognitive strategies to decide which formula applies to a given context. The recurring confusion between area and circumference, or between formula manipulation and substitution, reveals an over-reliance on rote memorisation—what Booth et al. (2017) call "procedural mimicry" without conceptual grounding.

Difficulty Changing the Subject of a Formula

The response illustrates difficulty manipulating formulas to isolate a required variable. Although the formula $D = S \times T$is correctly recalled, the subsequent rearrangement produces $T = s/D$, which incorrectly reverses the relationship between the variables. The calculation then proceeds with incorrect substitutions and inconsistent time conversions, resulting in an invalid final answer. This pattern reflects a procedural misunderstanding of algebraic manipulation within measurement formulas, where formula transformation is attempted mechanically without conceptual verification of the resulting relationship between variables.

Omitting Values from the Formula

The calculation of surface area demonstrates partial application of the formula $SA = (l \times w) + 2(l \times h) + 2(w \times h)$. However, one component of the formula is omitted during substitution, resulting in an incomplete representation of the surface area calculation. The steps indicate that only three expressions were evaluated instead of the full set required by the formula. This omission produces an incorrect intermediate value and ultimately an inaccurate total. Such responses suggest difficulty maintaining the full structure of multi-part formulas during calculation, a procedural lapse commonly observed when learners attempt to simplify complex expressions without fully understanding their components.

Incorrectly Copying the Formula

The formula presented as $V = L + h + w$demonstrates an incorrect transcription of the formula for volume. Instead of applying a multiplication relationship between dimensions, the formula is written as an addition expression. The subsequent step $3 + 8 \times h$further indicates confusion about the mathematical relationship between length, width, and height. This response reflects a procedural error occurring at the initial stage of problem solving, where incorrect copying or recall of a formula leads to an invalid solution pathway before calculation even begins.

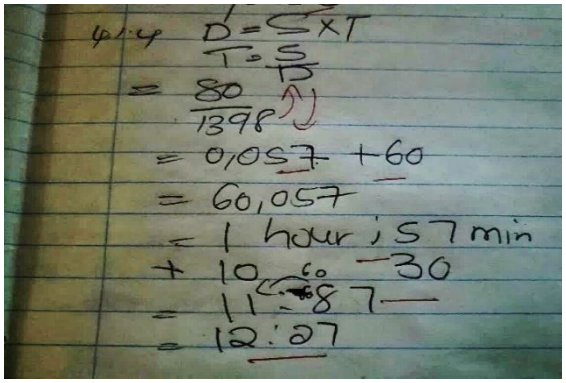
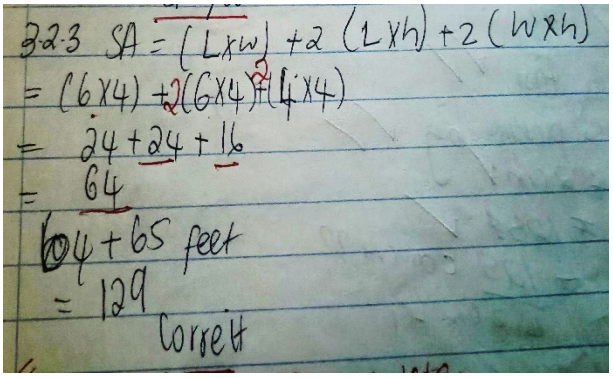
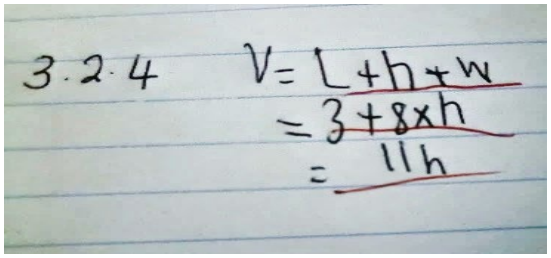
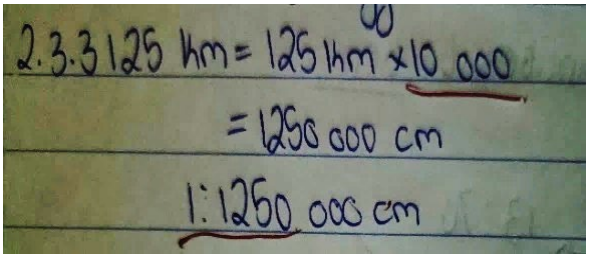
Incorrect Measurement of Distance on a Map

The final response attempts to convert a map distance into real-world distance but does not demonstrate the required measurement step. The conversion of $125\ km$into centimetres is performed without first determining the actual measured distance on the map using a ruler. As a result, the scale calculation is applied to an incorrect or assumed value. This indicates difficulty applying procedural steps required in map scale problems, where accurate measurement using physical tools is necessary before performing numerical conversions. The error therefore illustrates a procedural gap in transferring classroom algorithms to authentic measurement contexts involving physical representations such as maps.

Figure 6, illustrates procedural errors exhibited in learners' responses to the Free State Department of Education (DoE) June exam paper (Appendix J), in addition to the exam paper, the memorandum (Appendix K) and the addendum to the paper (Appendix L) are also attached. Such patterns demonstrate that procedural difficulties are not confined to abstract manipulation but extend to applied contexts, requiring integration of multiple measurement skills. Learners' inability to convert time accurately or measure physical distances correctly indicates that procedural lapses often stem from difficulties transferring learned algorithms to authentic tasks.

Figure 6

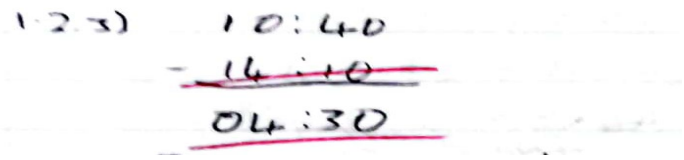
Procedural errors identified on learners' exam scripts

<table>
<tr>
<td>Failing to change the subject of the formula
 
(Transcription:) (4.1.4) $D = S \times T$
$T = \frac{S}{D}$
$= \frac{80}{1398}$
$= 0.057 + 60$
$= 60.057$
$= 1\ hour; 57\ min + 10:30$
$= 11:87$
$= 12:27$</td>
<td>Omitting values from the formula
 
(Transcription:) (3.2.3)
$SA = (l \times w) + 2(l \times h) + 2(w \times h)$
$= (6 \times 4) + (6 \times 4) + (4 \times 4)$
$= 24 + 24 + 16$
$= 64$
$= 64 + 65\ feet$
$= 129, correct$</td>
</tr>
<tr>
<td>Failing to copy formulas correctly
 
(Transcription:): (3.2.4) $V = L + h + w$
$= 3 + 8 \times h$
$= 11h$</td>
<td>Failing to measure distance
 
(Transcription:): (2.3.3)
$125\ km = 125km \times 10\ 000$
$= 1250\ 000\ cm$
$= 1:1250\ 000\ cm$</td>
</tr>
</table>

In addition, learners were required to calculate elapsed time in an applied context. One learner gave the following response.

Figure 7

Example of integrating multiple skills and concepts



(Transcription:) (1.2.3) 10:40

- 14:10

04:30

The learner could read the time (10:40) correctly from clock B; however, the learner struggled to subtract time intervals correctly to determine the elapsed time. Furthermore, the learner did not convert minutes into fractions of an hour when expressing the total time in hours. This indicates that the learner struggled to grasp the relationship between different units of time (hours and minutes) and convert from one to the other correctly.

These findings align with the literature that identifies procedural errors as a common challenge in mathematics education. Andriani and Nurhasanah's (2021) categories of procedural errors—misidentification and misgeneralisation—were evident in the learners' errors with unit conversions, formula application, and geometric calculations. Similarly, Guce (2017) highlighted errors in mathematical writing, such as incorrect grammar and misuse of symbols, which were observed in learners' responses in this study, too. Additionally, Baharuddin et al. (2021) highlighted errors in integer counting operations and quadratic surfaces, which resonate with the difficulties learners demonstrated in formula manipulation in this study.

The findings also extend the literature by highlighting that learners make procedural errors in applied tasks - such as practical measurement tasks— such as map reading and real-world calculations—as well as abstract tasks. This suggests that learners do not only make procedural errors in abstract mathematical tasks but also in applied tasks where they are required to integrate multiple skills and concepts.

The prevalence and persistence of these procedural errors suggest that learners possess fragmented procedural knowledge divorced from underlying conceptual reasoning. Their difficulties highlight a crucial pedagogical implication: procedural fluency in Measurement must be developed alongside conceptual comprehension and contextual application. Without such integration, learners continue to execute procedures mechanically, making predictable

errors under pressure. The following section therefore examines the deeper misconceptions underlying these procedural patterns, offering insight into why these errors persist even after repeated instruction.

5.4.2 Procedural misconceptions in Measurement

While the previous section focused on learners' observable procedural errors, this section explores the underlying misconceptions that drive those errors. Procedural misconceptions differ from simple errors in execution because they reflect deep-seated misunderstandings about how mathematical operations, units, and formulas relate to one another. In Mathematical Literacy (ML), these misconceptions are particularly concerning, as they reveal that learners are not merely applying procedures incorrectly but are constructing fundamentally flawed internal models of measurement processes. This section therefore interprets evidence from DBE diagnostic reports, teacher interviews, and learners' scripts to illustrate how these misconceptions develop and persist.

The 2022 and 2023 diagnostic reports published by the DBE (2022; 2023) highlight various procedural errors that reveal underlying misconceptions among learners in ML. These errors are not merely mistakes but indicate deeper misunderstandings of fundamental concepts. One notable issue is the misapplication of unit conversion (DBE, 2022). This error suggests that learners struggle with understanding how different units relate to one another—particularly, when distinguishing whether a given value should be scaled up or down. Instead of applying a logical approach to unit conversion, they resort to arbitrary operations, leading to incorrect solutions.

Another common error pertains to calculating perimeter, where learners conflate perimeter and area calculations, treating perimeter as a multiplication problem rather than an addition of linear dimensions (DBE, 2022). Learners' omission of brackets further indicate difficulty understanding the order of operations, leading to computational errors that affect accuracy. Additionally, some learners answered in square units, reinforcing the misconception that perimeter and area involve the same mathematical process.

Learners' difficulties with formula manipulation were also evident in the 2022 report (DBE, 2022). The inability to isolate variables in an equation suggests a lack of fluency in algebraic manipulation. Furthermore, failure to round correctly indicates that learners may not fully grasp the importance of precision and estimation in real-world mathematical applications. The

application of ratios was another problematic area (DBE, 2022). This error suggests that learners struggle to interpret ratios correctly, leading them to perform incorrect operations. Rather than seeing ratios as a proportional relationship requiring division, they default to multiplication, which distorts the intended calculation.

The 2023 DBE report also highlighted errors that stemmed from misinterpreting instructions. This procedural error suggests that some learners may misinterpret the question or struggle with test-taking strategies, leading them to provide answers that do not align with what was required. Incomplete data utilisation was another issue observed in the 2023 report. This highlights a tendency among learners to rely exclusively on visual representations without integrating textual information. Such an approach can lead to miscalculations, as critical data provided in written form is overlooked.

Additionally, the report indicated that learners struggled to connect related problems (DBE, 2023). This suggests that learners view mathematical problems in isolation rather than as interconnected steps leading to a complete solution. The inability to recognise how previous calculations contribute to later steps results in partial or incorrect answers. Furthermore, the misinterpretation of contextual information emerged as a recurring problem (DBE, 2023). This error indicates difficulty identifying relevant numerical information in word problems. Learners may struggle to filter out extraneous details and apply only the necessary values to their calculations.

Teachers' responses in interviews corroborated these procedural misconceptions. Mr Quenric noted:

> *"Another misconception is with calculating volume for irregular shapes. Learners sometimes try to use perimeter formulae instead of volume, which leads to confusion."*

Ms Zyphron observed:

> *"Learners struggle to change the subject of a formula because they do not understand the formula. They simply think it is good enough to substitute formulas and have no idea what each value refers to. And they do not understand what the subject is and cannot apply the method correctly."*

Ms Tarkis stated:

"Substituting diameter in the formula for C = 2πr, they confuse the diameter with the radius."

These areas of confusion illustrate how learners miscategorise formulas by surface features (e.g., the presence of multiplication or π) rather than conceptual meaning. Ms Zyphron's comment shows that procedural misconceptions often stem from symbolic detachment—learners manipulate symbols without linking them to real-world quantities. Ms Tarkis's observation further supports this interpretation: the misconception is not a recall error but a representational one, where learners fail to internalise proportional relationships between dimensions.

Analysis of examples of learners' work revealed similar patterns of misconceptions.

Confusing Radius and Diameter

The response demonstrates partial recall of the cylinder volume formula $V = \pi r^2 h$, indicating that the structural form of the formula is known. However, the value substituted for the radius reflects a confusion between **radius and diameter**, suggesting that the relationship between these two measures is not conceptually understood. The calculation proceeds correctly after substitution, which implies that the procedural steps are familiar, yet the conceptual basis of the variables remains unclear. The answer also retains millimetres without verifying unit consistency, pointing to limited attention to measurement units. This error therefore reflects a conceptual misunderstanding of measurement attributes combined with procedural execution.

Incorrect Unit Representation in Volume Calculation

The response shows correct recognition of the formula $V = \pi r^2 h$and an attempt to substitute numerical values appropriately. However, the final result is expressed in centimetres rather than cubic centimetres, indicating an incomplete understanding of dimensional units in volume calculations. Volume requires cubic units because three dimensions are involved in the measurement. The omission of the exponent suggests procedural familiarity with the formula but insufficient conceptual awareness of how units expand during volume calculations. The error therefore reflects a procedural mistake rooted in incomplete conceptual understanding of measurement units.

Multiplication Instead of Division

The sequence of calculations indicates uncertainty about the operations required to solve the measurement problem. The numerical manipulation suggests an attempt to combine values through multiplication and division without a clear conceptual interpretation of the quantities involved. Such errors frequently arise when learners attempt to follow remembered computational procedures rather than reasoning about proportional relationships or measurement contexts. The calculations therefore illustrate a procedural misconception in which arithmetic operations are applied mechanically rather than conceptually.

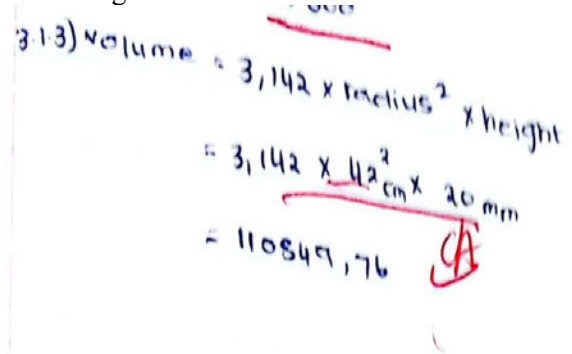
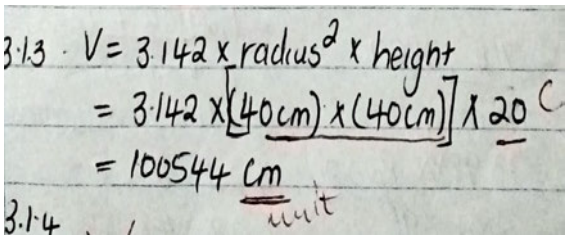
Confusing the Area of a Square with the Area of a Circle

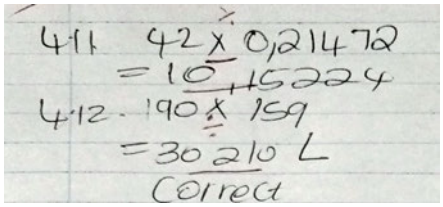
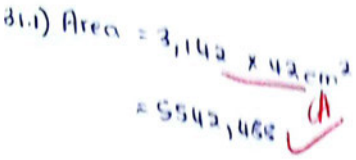
The calculation uses the formula $A = \pi r^2$, which corresponds to the area of a circle. However, the problem context requires determining the area of a square, where the appropriate formula would be $A = s^2$. This suggests that the formula was selected based on memorisation rather than interpretation of the geometric structure of the problem. The response illustrates a common misconception in measurement tasks where formulas are applied without analysing the characteristics of the shape involved. The error therefore represents a conceptual misunderstanding of geometric properties combined with formula overgeneralisation.

These misconceptions are conceptually revealing: they demonstrate that learners perceive formulas as interchangeable templates rather than context-bound representations, as illustrated in Figure 8 and evidenced in the learners' scripts. The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

Figure 8

Procedural misconceptions identified in learners' scripts

<table>
<tr>
<td>Confusing radius & diameter
 
(Transcription:) (3.1.3)
$Volume = 3.142 \times radius^2 \times height$
$= 3.142 \times 42^2 \times 20mm$
$= 110849.76$</td>
<td>Using incorrect units
 
(Transcription:) (3.1.3)
$V = 3.142 \times radius^2 \times height$
$= 3.142 \times [(40cm) \times (40cm)] \times 20$
$= 100544\ cm$</td>
</tr>
</table>

Multiplication instead of division	Confusing area of a square with a circle
 (Transcription:) (4.1.1) 42 × 0.21472 = 10.15224 (4.1.2) 190 ÷ 159 = 30210 L = Correct	 (Transcription:) $A = 3.142 \times 42\ cm^2$ $= 5542.488$

Furthermore, learners had to respond to a question requiring them to "*Convert the bar scale on the map to a ratio scale in the unit form*, i.e. 1:….." Learners had to respond as indicated in the marking guideline (Appendix K) in Figure 9 below.

Figure 9

Example of the role of practical measurement tasks

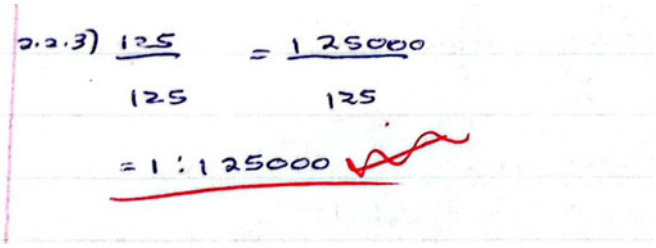
2.3.3	Measured Bar scale = 4,3 cm ✓A 4,3 cm = 125 km ✓MA 4,3 cm = 12 500 000 cm ✓C 1 : 2 906 976,744 ✓CA NB: **Check the measurement on the final paper**	(±1) 1A Measured value. 1MA equating to 125 1C conversion 1CA correct answer (4)

This task was designed to assess learners' ability to apply their understanding of scale conversion within a practical measurement context. However, analysis of the responses revealed that several learners struggled to correctly convert the bar scale to a ratio scale.

A response of one learner is shown in Figure 10, where the learner incorrectly converted a bar scale into a ratio scale. This illustrates that even when learners recall procedural steps, they may fail to apply them meaningfully—indicating procedural understanding without conceptual anchoring.

Figure 10

Example of the role of practical measurement tasks



(Transcription:) (2.3.3) $\frac{125}{125} : \frac{125000}{125} = 1:25\ 000$

The learner's incorrect response illustrates a procedural misconception; specifically, a miscalculation converting units of the relationship between the map scale and actual distance. This suggests that while learners may recognise the procedural steps involved, they often fail to integrate conceptual understanding with numerical computation.

These findings are consistent with existing literature on procedural misconceptions in mathematics. Booth et al. (2017) and Ndemo and Ndemo (2018) identified misapplication of formulas and limited understanding of mathematical concepts as common sources of procedural errors, which align with the learners' struggles with formula manipulation and unit conversions in this study. Similarly, Quinio and Cuarto (2023) highlighted misconceptions related to procedural knowledge, while in this study learners exhibited difficulty interpreting geometric problems and changing the subject of formulas. The findings also extend the literature by highlighting integrated practical measurement tasks, such as map reading and real-world calculations.

The evidence demonstrates that procedural misconceptions in ML are systemic rather than incidental. They reflect learners' attempts to make sense of measurement through intuitive but incorrect reasoning patterns. The next section turns to computational challenges, which further reveal how arithmetic inaccuracies compound these underlying misconceptions.

5.5 Theme 2: Computational challenges in Measurement

In mathematical problem-solving, computational errors are often regarded as a subset of procedural errors. Procedural errors encompass mistakes made during the execution of problem-solving procedures, including errors in calculations, which are commonly referred to as computational errors (Dorner et al., 2025; Delastri & Lolang, 2023; Toma et al., 2021;

Susanti & Taufik, 2021; Wu et al., 2024). Therefore, within conventional classifications, computational errors are considered a specific type of procedural error.

Although computational errors are traditionally viewed as a form of procedural error, this study treats them as a standalone category. Following the distinction made by Delastri and Lolang (2023) and Wu et al. (2021), computational and procedural errors are analysed as separate themes to provide deeper insight into how Mathematical Literacy learners' challenges in Measurement arise both from procedural misunderstandings and from arithmetic inaccuracies. This differentiation allows the study to capture a more nuanced understanding of learners' error patterns and teachers' remedial strategies. Thus, this section presents and analyses computation errors in Measurement, focusing on the challenges learners face in ML.

5.5.1 Computational errors

Computational errors are defined as mistakes made during the calculation phase of problem-solving. These errors can result from manual calculation slips, such as addition or multiplication mistakes, or from limitations in numerical precision within computational tools. Additionally, round-off errors can occur during numerical computations due to the finite precision of numerical representations, leading to small discrepancies between the true value and its approximation (Toma et al., 2021; Susanti & Taufik, 2021 Wu et al., 2024).

However, as the findings show, these mistakes often reveal more than carelessness—they indicate shallow internalisation of mathematical relationships and limited monitoring by learners of their own problem-solving processes.

The DBE's 2022 diagnostic report noted the following computation errors:

> *Many candidates worked with mixed units (mm and cm) (DBE, 2022; p. 192(b)). Some candidates could not round off to the nearest ten (DBE, 2022; p. 193(h)). Candidates multiplied instead of dividing to convert from feet to metres (DBE, 2022; p. 194(e)). Most candidates used incorrect values to calculate the percentage discount. Some candidates used the incorrect denominator (DBE, 2022; p. 195(f))*.

The DBE's 2023 diagnostic report highlighted similar computation errors:

> *Some candidates added the six zeroes but did not remove the comma, arriving at an incorrect answer of 2,7000000 (DBE, 2023; p. 208(a)). Some candidates added mixed*

units or could not correctly convert grams to kilograms (DBE, 2023; p. 208(b)). Many candidates could not apply the ratio concept and lost valuable marks. Most candidates did not divide 5.5 bags of cement by 0.75 to determine the number of bags required to make 1 m³ of concrete. Early rounding off was also a problem (DBE, 2023; p. 208(e)). Most candidates divided the distance in miles by 1.151 instead of multiplying by 1.151. Candidates were supposed to convert first to miles, then to km (DBE, 2023; p. 210(e)).

These recurring challenges illustrate a pattern of inattentive calculation combined with weak conceptual checking. The persistence of incorrect conversions across years suggests that learners are not applying proportional reasoning to verify whether their results are reasonable in context.

Teacher's interviews corroborated the findings from the two diagnostic reports (DBE, 2022; 2023). Teachers consistently noted that computational errors often stem from premature rounding, incorrect conversions, and cognitive overload. Mr Quenric noted:

> "*They also make errors with rounding off numbers, especially when they're working with time, but I don't have enough time to teach them to round properly every time."*

Ms Luneth observed:

> *"Learners also tend to round too early in multi-step problems, significantly affecting the final answer. I've noticed this, particularly in questions where they need to convert time units or calculate using pi (π)."*

Mr Orvex stated that he observed a

> "*common error with rounding. Learners sometimes round off too early in a multi-step calculation, leading to a very inaccurate final answer. I always remind them to only round off at the end."*

These reflections suggest that computational errors are not random but occur because learners struggle to sustain attention over extended problem-solving sequences. Their reliance on early rounding implies a coping mechanism for cognitive strain, simplifying tasks at the cost of accuracy.

Difficulty Converting Between Units

The response illustrates difficulty with unit conversion within a time–distance relationship. Although the formula $D = S \times T$is correctly recalled, the subsequent manipulation of values reveals confusion when converting minutes into hours. The calculation mixes fractional hours and minutes without maintaining a consistent unit structure, leading to the incorrect expression 11:59125. This indicates a computational error arising from incomplete understanding of time conversion procedures, particularly the relationship between minutes and hours. The error reflects procedural manipulation of numbers without maintaining conceptual clarity about the units being used.

Premature Rounding During Multi-Step Calculations

The solution demonstrates premature rounding of intermediate results during a multi-step conversion process. The initial calculation correctly converts gallons to litres using the factor $1L = 0.264172$, producing a precise value of 158.9873264 litres. However, rounding the value to 159 L before completing the next step introduces a small computational distortion that carries forward into subsequent calculations. While the overall approach is mathematically appropriate, the early rounding indicates limited awareness of the importance of maintaining precision throughout multi-step calculations until the final answer is obtained.

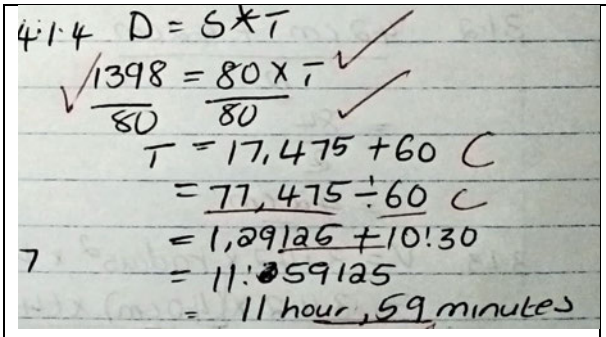
Incorrect Rounding of Decimal Values

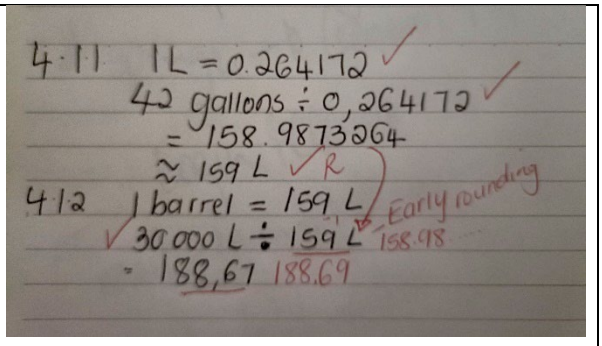
The final calculation produces the value 188.6792453, which is then rounded to 189 barrels. However, the task required rounding to two decimal places, not to the nearest whole number. The rounding procedure therefore does not align with the instructions of the problem. This indicates a computational error related to rounding rules, where numerical values are approximated incorrectly due to misunderstanding of the specified level of precision. The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

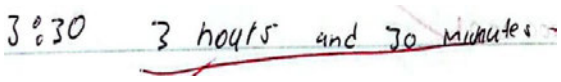
Figure 11

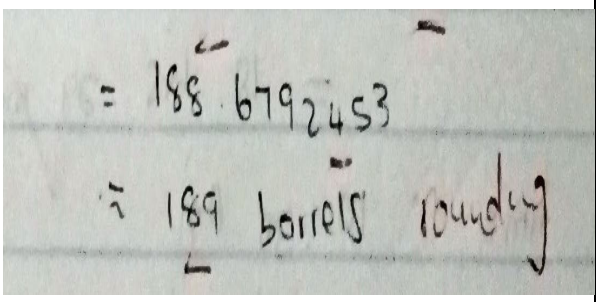
Computational errors identified in learners' scripts

Struggling to convert between units	Premature rounding

<table>
<tr>
<td> 

(Transcription:) (4.1.4) D= $S \times T$
$\frac{1398}{80} = \frac{80 \times T}{80}$
T= 17.475 + 60
$= 77.475 \div 60$
$= 1.29125 + 10:30$
$= 11:59125$
$= 11\ hour, 59\ minutes$</td>
<td> 

(Transcription:) (4.1.1) $1L = 0.264172$
$= 42\ gallons \div 0.264172$
$= 158.9873264$
$\approx 159L$
(4.1.2) $1\ barrel = 159\ L$
$= 30\ 000\ L \div 159\ L$
$= 188.67$</td>
</tr>
<tr>
<td>Relying on the calculator without steps
 

(Transcription:)3: 30 =
3 hours and 30 minutes</td>
<td>Incorrect rounding of numbers (must round to 2 decimals)
 

(Transcription:) = 188.6792453
$= 189\ barrels$</td>
</tr>
</table>

Overreliance on the Calculator Without Showing Procedural Reasoning

The response indicating that 3:30 equals 3 hours and 30 minutes suggests that the calculation was performed mentally or through a calculator without demonstrating the conversion process. While the interpretation itself is not incorrect, the absence of visible steps makes it difficult to verify how the value was derived. This type of response reflects a common classroom pattern in which learners rely heavily on calculators or mental shortcuts without documenting the procedural reasoning required in formal problem solving. Additionally, as seen in figure 11, one learner relied on a calculator both solve a problem without conceptual understanding; they bypassed critical internalisation processes essential for procedural fluency. Instead of using the calculator to enhance their problem-solving strategies, they allowed it to replace meaning-making, leading to procedural blindness.

For example, as shown in the marking guideline (Appendix K) in Figure 12. The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

Figure 12

Example highlighting a dual-layered error from a marking guideline

1.2.3	14:10 – 10:40 ✓ MA = 3 hours and 30 minutes = 3,5 hours ✓ C	1MA subtraction 1C conversion to hours (2)	M L1 M

The learner used a calculator as follows: $14°10° - 10°40° = 3°30'$, which indicates 3 hours 30 minutes; however, the learner lost marks as they did not show the necessary steps and could not convert to hours for the final answer as requested.

These findings are consistent with the existing literature on computational errors in mathematics. Morales Brignac (2022) and Rashid et al. (2021) identified misunderstandings of units and incorrect application of formulas as common sources of errors, which aligns with learners' struggles with unit conversions and formula manipulation in this study. Toma et al. (2021) highlighted errors in rounding, which resonate with learners' incorrect and premature rounding in this study.

The findings extend the existing literature by identifying a dual-layered error where learners make computational mistakes and fail to engage with the reasoning process, leading to procedural inaccuracies. The next section presents and analyses computational misconceptions.

5.5.2 Computational misconceptions

Computational misconceptions in Measurement are deeply rooted misunderstandings that persist even after instruction (Guerra-Reyes et al., 2024; Majeed et al., 2023; Ili, 2022). A recurring error involves the incorrect handling of units. The 2022 DBE report highlights that many candidates worked with mixed units (mm and cm) in the same calculation, indicating a fundamental misconception about unit consistency. Similarly, the 2023 DBE report notes that learners struggled with unit conversions, particularly in tasks requiring gram to kilogram conversions, suggesting that they lacked adequate conceptual and procedural knowledge of

unit relationships. Another significant error is the incorrect application of multiplication and division in conversion calculations. The 2022 DBE report observes that some candidates multiplied instead of dividing to convert feet to metres, while the 2023 DBE report found candidates divided miles by 1.151 instead of multiplying. These errors reflect a misconception about the directionality of unit conversions, where learners failed to determine when to scale values up or down.

Rounding errors also pose a challenge. The 2022 DBE report notes that candidates could not round off to the nearest ten, and the 2023 DBE report highlights early rounding as a problem in ratio-based calculations, indicating a lack of procedural fluency or understanding of its impact on accuracy. Misinterpretation of numerical values and incorrect denominators further illustrate computational misconceptions. The 2022 DBE report states that some candidates used incorrect denominators in percentage calculations, revealing a misunderstanding of fraction-to-percentage conversions. Similarly, the 2023 DBE report describes candidates adding six zeroes but failing to remove a comma, resulting in incorrect numerical notation and place value errors. Difficulties applying ratios further demonstrate a conceptual gap in proportional reasoning. The 2023 DBE report notes that many candidates could not apply the ratio concept. This suggests learners struggled with the logic behind ratios, misapply operations or fail to grasp proportional relationships.

The findings from the interviews conducted with teachers in 2024 for this study corroborate the findings from the diagnostic reports, suggesting that learners' misconceptions identified in 2022 and 2023 persisted. In this study, Ms Luneth noted learners' misconceptions

> *"with unit conversions, particularly when moving between millimetres, centimetres, and meters. Learners might incorrectly assume that conversions are linear, often forgetting that they need to square or cube the units in area and volume calculations."*

Mr Orvex observed another misconception:

> *"I see it with time calculations, especially when converting between hours and minutes. For example, they might think that 1.5 hours equals 1 hour and 50 minutes instead of 1 hour and 30 minutes."*

Ms. Zyphron stated:

"Learners also do not know units of measurement, thus cannot distinguish whether they are working with volume or area if the unit of, for example., cm³, is given."

These remarks highlight that learners' computational misconceptions are hierarchical misunderstandings—they fail to conceptualise how units scale across dimensions (linear, area, volume) and how base-10 relationships influence conversions.

Learners' exam scripts revealed similar patterns of misconceptions. Learners omitted units in their final answers, demonstrating a lack of awareness of measurement conventions. Learners confused time formats, mistaking 24-hour time for 12-hour time and vice versa. The examples provided in Figure 13 highlight some of the computational misconceptions that learners exhibited on exam scripts. The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

Figure 13

Computational misconceptions identified in learners' scripts

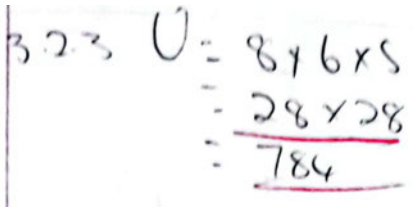
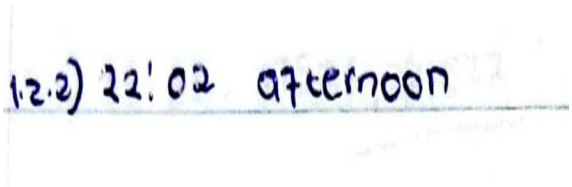
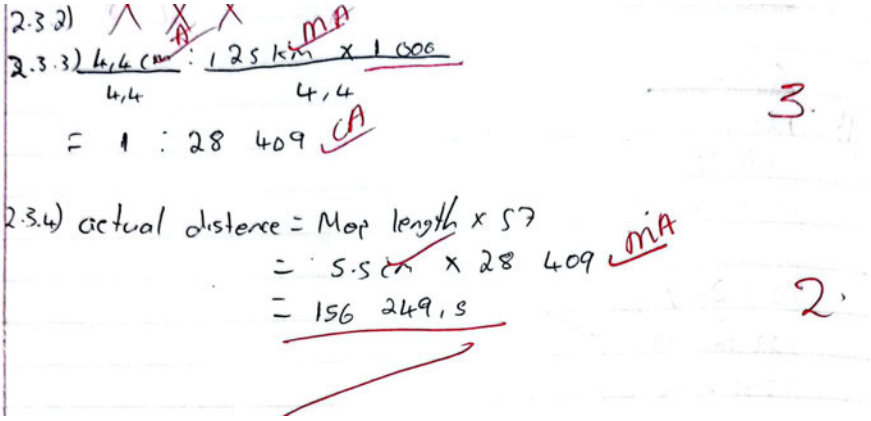
Omitting units	Mistaking time formats
	
(Transcription:) (3.2.3) $V = 8 \times 6 \times 5$ $= 28 \times 28$ $= 784$	(Transcription:) (1.2.2) $22{:}02\ afternoon$

Figure 14 provides an example of a learners' response that demonstrates cascading computational errors in scale application, where an initial mistake (e.g., in scale derivation) propagated through subsequent calculations, compounding inaccuracies. These patterns, illustrated in Figures 13 and 14, exemplify the cumulative nature of computational misconceptions: once learners misrepresent a base relationship, every dependent calculation inherits the distortion. The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

Figure 14

Example of cascading computational errors in scale application



(Transcription:) (2.3.3) $\frac{4.4\ cm}{4.4} : \frac{1.25\ km}{4.4} = 1:28\ 409$
(2.3.4) $actual\ distance = map\ lenght \times 57 = 5.5\ cm \times 28\ 409 = 156\ 249.5$

Instead of the computation demonstrated in the marking guide:

Figure 15

Marking guideline for cascading computational errors

2.3.4	Measured distance = 5,6 cm ✓A $\frac{5,6 \times 2\,906\,976,744}{100\ 000}$ ✓MA ✓C = 162,79 km ✓CA Reading from table 170 km ✓RT He is correct ✓O	1A measured value ((±1) 1MA using the no scale 1C conversion 1CA correct answer 1RT correct distance 1O Conclusion (6)	**MP L4 M**
		[27]	

These findings align with the existing literature, which identifies computational misconceptions as a significant barrier to mathematical proficiency. Makonye and Fakude (2016) posit that misconceptions stem from learners' reliance on rote memorisation rather than a deep understanding of mathematical operations, leading to mistakes when encountering non-routine problems. Tan Sisman and Aksu (2016) found that learners had misconceptions about spatial measurements, such as believing that all rulers are 30 cm long and confusing the area formula with the perimeter formula.

These findings demonstrate that computational misconceptions in ML arise from learners' failure to reconcile mathematical abstraction with everyday experience. Many rely on intuitive reasoning, such as assuming that bigger numbers mean bigger quantities, which leads to distortions when dealing with inverse operations like division in unit conversions.

The findings in this study also extend the literature by identifying four new types of errors:1) cascading computational errors in scale application; 2) unit dissociation and symbolic detachment; 3) unit neglect and the breakdown of comparative reasoning; and 4) failure to cross-check computational results with external references.

These findings highlight how misconceptions in ML are interconnected and cumulative. 'Cascading computational errors in scale application' shows how an initial mistake, such as incorrect scale derivation—as seen in Question 2.3.3, where the learners had to calculate the scale and propagate through subsequent calculations, where learners had to use the scale calculated in 2.3.3 to calculate the actual distance in 2.3.4. 'Unit dissociation and symbolic detachment' reveals difficulty connecting numbers to real-world contexts. 'Unit neglect and the breakdown of comparative reasoning' prevents self-correction when units are omitted. 'Failure to cross-check computational results with external references' also underscores a lack of metacognitive awareness, where learners fail to verify their answers against external data.

These categories illustrate that learners' misconceptions are systemic and self-reinforcing. They reveal a pattern where computational and conceptual weaknesses converge, resulting in persistent misunderstandings that transcend specific tasks. The next section builds on this discussion by analysing conceptual challenges, exploring how deeper misunderstandings of measurement principles underpin both the procedural and computational difficulties observed in this study.

5.6 Theme 3: Conceptual challenges in Measurement

Conceptual challenges in Measurement extend beyond procedural or computational inaccuracies; they reflect deep-seated misunderstandings of the fundamental ideas, relationships, and representations that underpin measurement concepts. While procedural and computational difficulties show how learners struggle to *do* mathematics, conceptual challenges reveal how they struggle to *understand* what they are doing. In Mathematical Literacy (ML), where learners must interpret mathematical representations of real-world phenomena, conceptual understanding serves as the bridge between abstract reasoning and

contextual application. This section therefore examines conceptual errors and misconceptions identified in DBE diagnostic reports, teacher interviews, and learners' exam scripts, illustrating how learners' misunderstandings of definitions, relationships, and dimensional reasoning shape their overall struggles with measurement.

5.6.1 Conceptual errors in Measurement

Conceptual errors in Measurement stem from the misunderstanding of fundamental mathematical concepts, such as the difference between radius and diameter, area and volume, and the correct application of formulas. These errors have been found to significantly impact their ability to solve measurement-related problems accurately (Sanina & Sokolov, 2021; Roell et al., 2019). The 2022 DBE diagnostic report noted that learners made the following conceptual errors:

> *Some candidates still confused diameter and radius. Many candidates used diameter instead of radius. Some could not square the radius/diameter. Most candidates added the last part instead of subtracting. Candidates failed to use the formula (DBE, 2022; p. 193(c)). Many candidates could not simplify the ratio or wrote the ratio as a fraction or wrote the ratio in reverse (DBE, 2022; p. 194(d))*.

The 2023 DBE diagnostic report highlighted similar conceptual errors:

> *Many candidates did not know that a square is a special type of rectangle with the length equal to the width, hence they were unable to calculate the volume of the square hole (DBE, 2023; p. 208(c)). Most candidates substituted the diameter instead of the radius into the given formula, and some did not square the radius to calculate the area of the triangle (DBE, 2023; p. 209(d))*.

These findings point to more than factual inaccuracy; they indicate a lack of conceptual integration. Learners appear to store definitions and formulas as disconnected facts without understanding their relational structure. For instance, the confusion between radius and diameter shows an absence of proportional reasoning, while the failure to recognise that a square is a type of rectangle signals categorical thinking errors—an inability to perceive hierarchical relationships among geometric figures. Such patterns suggest that learners approach measurement through memorised procedures rather than through conceptual models that explain why formulas work as they do.

In this study, interviews with teachers corroborated the findings reported by the DBE and provided additional insight into how these conceptual errors manifest in classrooms. Mr Quenric noted:

> *"I see a lot of confusion with basic things, like the radius and diameter. They don't always get the difference. And, to be honest, sometimes I struggle to explain it in a simple way."*

Ms Luneth stated:

> *"One misconception that often comes up is the confusion between radius and diameter. Learners sometimes struggle to understand that the diameter is twice the radius, and they mistakenly substitute the diameter in formulas that require the radius—especially in volume or circumference calculations."*

Ms Zyphron stated:

> *"Learners struggle in distinguishing between area and volume."*

Ms Tarkis stated:

> *"Learners don't know the difference between volume and capacity."*

Mr Orvex highlighted a common misconception about the relationship between volume and surface area:

> *"Learners often think that if two objects have the same surface area, they must have the same volume. They don't always understand that the shape and distribution of the dimensions can affect the volume, even if the surface area is the same."*

Mr Vexora emphasised:

> "*Learners confuse volume with other measurements such as area or perimeter—for example, calculating the box's surface area instead of the volume."*

These comments reveal that even experienced teachers encounter challenges translating abstract geometric relationships into accessible explanations. The persistence of these errors across contexts suggests that conceptual misunderstandings are not incidental but are

systematically reinforced through instruction that privileges formula recall over conceptual reasoning.

Analysis of the learner responses presented in Figure 16 reveals several conceptual misunderstandings related to definitions, contextual interpretation, and justification of mathematical reasoning. One recurring difficulty involved defining key Mathematical Literacy concepts accurately. For instance, the concept of a floor plan was expected to be defined as a scaled drawing viewed from above, yet one response described it simply as "the space," indicating an incomplete conceptual understanding of the term. Another response defined a floor plan as "a 2D view of a building from the top," which partially captures the idea but omits the critical notion of scale and representation used in architectural drawings. These responses suggest that while some descriptive features of the concept were recognised, the formal mathematical meaning of the term remained unclear.

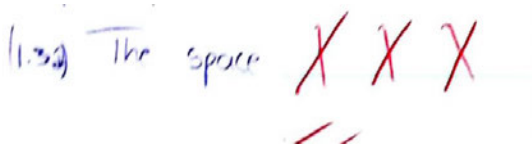
Further analysis also shows difficulty in defining concepts within the correct mathematical context. Although elements of the concept were identified, the responses lacked precision and did not fully reflect the purpose of floor plans as scaled representations used for measurement and spatial interpretation. This indicates a conceptual gap between everyday interpretations of space and the formal representation used in Mathematical Literacy tasks.

In addition, the scripts reveal challenges in justifying answers mathematically. In one example, calculations were performed to evaluate a salesperson's claim regarding the capacity of barrels, but the reasoning provided did not clearly explain the conclusion reached. While numerical manipulation was attempted, the explanation linking the calculation to the claim remained unclear. Similarly, another response showed a sequence of calculations leading to an incorrect final result of 750 litres. The working steps indicate uncertainty in selecting and applying appropriate formulas, reflecting a broader conceptual misunderstanding of how measurement formulas relate to real-life contexts, as shown in Figure 16. The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

Figure 16

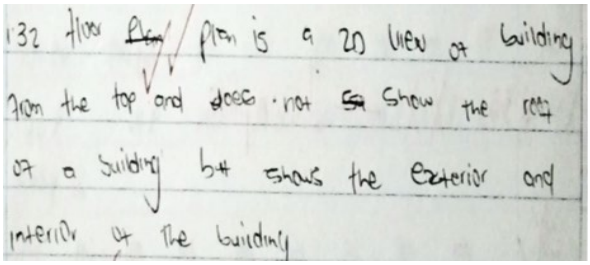
Conceptual errors identified in learners' scripts

Struggling to define concepts



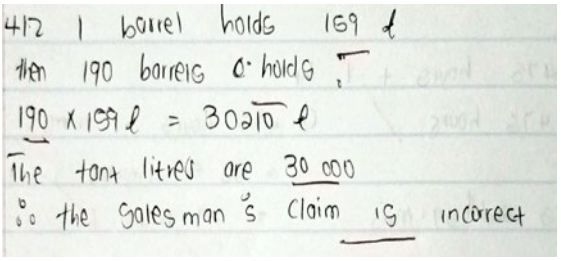
(Transcription:) (1.3.2) *The space*

Struggling to define in context

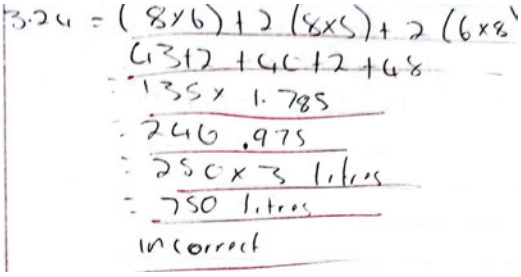


(Transcription:)
(1.3.2) *floor plan is a 2D view of a building from the top and does not show the roof of a building but shows the exterior and interior of the buiding*

Could not justify their answers



(Transcription:) (4.1.2)
1 *barrel holds* 159 *l then* 190 *barrels holds* 190 × 159 *l* = 30210
the tont litres are 30 000
∴ *the saleman's claim is incorrect*



(Transcription:) (3.2.4)

$$= (8 \times 6) + 2(8 \times 5) + 2(6 \times 8)$$
$$= 43 + 2 + 40 + 2 + 48$$
$$= 135 + 1.785$$
$$= 246.975$$
$$= 250 \times 3\ litres$$
$$= 750\ litres$$
$$= incorrect$$

These findings are consistent with the existing literature on conceptual errors in mathematics. Hasibuan et al. (2022) report errors in problem-solving steps and logical reasoning, which resonates with the difficulties exhibited learners' work in this study: difficulty defining concepts and justifying answers due to a lack of understanding of the questions, carelessness in calculations, and insufficient knowledge of problem-solving steps. Yasseen et al. (2020) found that these errors can significantly impact learners' performance and achievements in mathematics, hindering their ability to comprehend new concepts and apply mathematical principles accurately.

The findings of this study also extend the literature by highlighting the importance of contextualisation in measurement tasks, as shown in the examples in Figure 16. Conceptual

errors reflect a deeper level of misunderstanding than procedural or computational mistakes. They demonstrate that learners' knowledge structures are fragmented and poorly connected, preventing the integration of new information. The next subsection explores these challenges further by analysing the *misconceptions*—that is, the flawed internal logics—that shape learners' understanding of measurement concepts.

5.6.2 Conceptual misconceptions in Measurement

While conceptual errors reflect incorrect application of formulas or definitions, underlying misconceptions stem from how learners mentally represent or internalise measurement concepts. These misconceptions often result from inadequate conceptual encoding and a flawed understanding of the relationships between mathematical ideas. For example, confusion between radius and diameter is not merely a failure to recall the definitions of these concepts but is often the result of perceiving both as indistinguishable linear measures without grasping the relational structure: that the diameter is twice the radius. Learners appear to encode the radius and diameter as interchangeable lengths, rather than understanding the proportional relationship between them. This surface-level encoding leads to frequent substitution of the diameter in formulas requiring the radius and the failure to square the radius where appropriate.

Similarly, learners' difficulty with ratios—such as writing them in reverse order, or as fractions—may stem from a misconception about the directionality and purpose of ratios. Learners often perceive ratios as static numbers rather than relationships between quantities, indicating an incomplete conceptualisation of proportional reasoning. The misconception that a square is not a rectangle highlights a categorical thinking error, where learners view geometric shapes as mutually exclusive rather than hierarchical. This misunderstanding impedes their ability to apply generalised formulas and to recognise shared properties between shapes. Another pervasive misconception lies in the interpretation of area, volume, and capacity. Many learners treat these as interchangeable terms, likely because they conflate the contextual use of space with mathematical dimensionality. For instance, learners may see both area and volume as simply 'space occupied', without understanding that area pertains to two-dimensional space while volume measures three-dimensional space. This results in the inappropriate application of formulas and misunderstanding of the significance of units (e.g., cm^2 vs. cm^3).

Learners' confusion between surface area and volume also reveals a misconception that equal surface areas imply equal volumes. This stems from a lack of understanding of how three-

dimensional shape configuration affects volume beyond surface dimensions. Learners may intuitively think that an object that appears to be bigger, or one with a larger surface, must hold more volume, showing reliance on visual or perceptual cues rather than formal geometric reasoning. The responses displayed on learners' scripts reflect these misconceptions. For instance, defining a floor plan as 'the space' instead of 'a scaled drawing viewed from above' suggests a misunderstanding of the representational nature of mathematical models. Rather than recognising a floor plan as an abstract representation, learners interpreted it as a literal physical space, indicating difficulty shifting between real-world objects and their symbolic mathematical representations.

These findings align with previous studies on conceptual misconceptions in Measurement. Kusmaryono et al. (2020) found that elementary school teachers often harboured misconceptions, with the result that they modelled errors during instruction. This is relevant to the study, as it raises the possibility that the conceptual errors displayed by learners may be linked to teachers' instructional approaches lacking conceptual clarity. Additionally, Sari and Masriyah (2022) highlight how misconceptions in fundamental mathematical concepts, such as quadrilaterals and linear systems, persist across different levels of mathematical ability, as in this study Grade 12 learners continued to struggle with concepts in Measurement. The results of this study also support the argument made by Fardah and Palupi (2023) that systematic errors in mathematical reasoning stem from misconceptions about definitions, classifications, and correlations—which, in this study, was evident in the difficulties learners displayed calculating volume and elapsed time. The findings of this study also extend the literature by highlighting the intersection of Measurement and proportional reasoning, as seen in the responses provided by learners in Figure 16, above.

The following section builds on this analysis by exploring how learners' difficulties in interpreting and applying measurement knowledge compound these conceptual gaps, further influencing their performance in ML tasks.

5.7 Theme 4: Interpretation and application challenges in Measurement

Beyond procedural, computational, and conceptual limitations, many learners in Mathematical Literacy (ML) also experience difficulties with interpreting and applying measurement knowledge in context. These challenges represent the final layer of misunderstanding identified in this study and are particularly concerning because they hinder learners' ability to transfer

mathematical reasoning to real-world situations—the central goal of ML. Interpretation challenges occur when learners misread or misrepresent information embedded in tasks, while application challenges involve the inability to employ correct mathematical strategies or concepts in authentic contexts (Wardah et al., 2021; Bansilal & Debba, 2012). This section draws on DBE diagnostic reports, teacher interviews, and learners' scripts to explore how these difficulties manifest, what they reveal about learners' reasoning processes, and how they relate to the broader patterns of misconceptions discussed earlier.

5.7.1 Interpretation errors

Interpretation errors arise when learners misread questions, misunderstand contextual cues, or misinterpret mathematical representations such as diagrams, tables, and scales. Learners' interpretation errors were found across all three data sources. The 2022 DBE diagnostic report states that *"some candidates referred to instruments of time and not time format" (DBE, 2022; p. 190(b))* and *"many candidates did not include that the time was in the afternoon and lost one mark. Alternatively, candidates could not differentiate between 'to' and 'past' in writing time in words" (DBE, 2022; p. 190(c))*. These errors suggest a fundamental misunderstanding of time measurement and its representation. This indicates a persistent inability to contextualise measurement problems, which show that learners struggle to connect mathematical notation to linguistic or contextual meaning—a problem rooted in weak semantic interpretation rather than arithmetic skill.

Additionally, the 2022 further report that "*many candidates could not differentiate between cooking time and preparation time when reading the recipe. Most could not subtract time"* and that "*the request to verify was misinterpreted in the given context" (DBE, 2022; p. 193(g))*. The 2023 diagnostic report corroborates this, noting that *"many candidates could not interpret the question that the post would occupy some of the volume of the hole" (DBE, 2023; p. 208(d))*. It also states that "*many candidates only worked with the drawn diagrams and not the full extract" (DBE, 2023; p. 208(f))*.

Such examples demonstrate that interpretation errors often stem from learners' selective attention to visual rather than textual information, suggesting that they treat diagrams as self-contained rather than as components of an integrated problem context. This behaviour reflects a fragmented cognitive approach to problem-solving, in which learners fail to coordinate multiple sources of information—a critical skill in ML tasks involving real-life data.

Interviews conducted with teachers during this study echoed these findings. Mr. Quenric noted:

> "*When learners try to convert units, it's all over the place. I have the same issue sometimes with remembering all the rules for converting between centimetres, meters, and millimetres. Learners try adding different units, like meters to centimetres, without converting".*

Ms Zyphron stated:

> *"Learners struggle reading data from a table and to apply it to the context".*

Ms Tarkis highlighted:

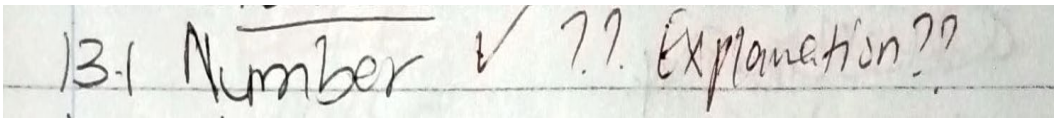
> *"They don't know the difference between mm and cm".*

These observations align with the diagnostic reports, underscoring a systemic issue in interpreting measurement concepts. These comments suggest that interpretation difficulties often originate in poor representational literacy—learners can read numerical data but cannot infer meaning or relevance from it.

Learner scripts further revealed that learners fail to read and interpret questions correctly, leading to irrelevant or incomplete responses. Additionally, some learners only partially answer questions that require multiple responses. For example, learners were required to identify the type of scale used and then provide an explanation of what that scale means (question attached in Appendix J). The correct response would have been: "Number Scale/Ratio/Numeric, 1 cm on the scale drawing is 50 cm in real life". However, one learner responded partially, without indicating that it is a scale and what the number scale 1:50 means, as shown in Figure 17.

Figure 17

Example of a partial response

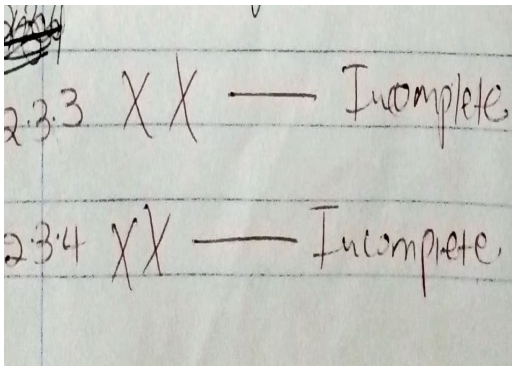
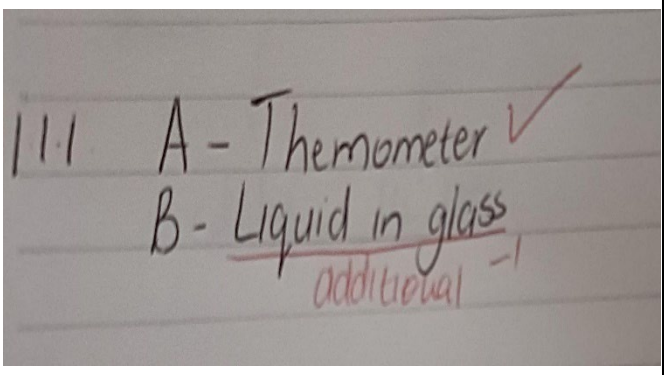


(Transcription:) (1.3.1) $Number$…..

Furthermore, learners provided multiple answers for questions that required a single answer, hoping for correctness, but lost marks—as if a single answer is required and the learner provides additional answers, marks are deducted for each additional response provided. These findings suggest that learners often misinterpreted the requirements of measurement tasks, leading to errors in their responses. Figure 18 provides examples of learners' interpretation errors in Measurement in ML. The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

Figure 18

Interpretation errors identified in learners' scripts

Incomplete answers	Providing multiple answers
	
(Transcription:) (2.3.3) $blank\ (no\ answer)$ (2.3.4) $blank\ (no\ answer)$	(Transcription:) (1.1.1) $A = Themometer$ $B = Liquid\ in\ glass$

These patterns, illustrated in Figures 17 and 18, indicate that learners interpreted questions syntactically rather than semantically: they focused on surface cues rather than understanding the intent behind the task.

Interpretation errors reveal that learners have not internalised strategies for negotiating meaning between everyday language and mathematical representation. They treat symbols and words as isolated pieces of information, rather than as part of a coherent, communicative system. As Verdejo et al. (2021) argue, errors in interpretation often occur at the stage of simplification and validation, when learners must align the problem's linguistic and mathematical components. In this study, that misalignment was particularly evident when learners misread context-based measurement questions, confirming that interpretation difficulties are a key barrier to functional mathematical literacy.

5.7.2 Application errors

Application errors occur when learners fail to transfer mathematical procedures and concepts appropriately to real-world problems. These errors reveal weaknesses not only in procedural fluency but also in the ability to reason contextually and adaptively. The DBE's 2022 diagnostic report highlighted that *"candidates did not answer questions in context and gave general answers" (DBE, 2022; p. 193(f))*. The report also stated that *"some candidates could not work with fractions or convert from millilitres to litres. Many multiplied instead of dividing. Some candidates converted from cm to mm incorrectly" (DBE, 2022; p. 193(i))*.

These errors reflect a lack of procedural fluency in the form of failure to comprehend the text and, therefore, failing to apply the appropriate strategy to solve the question.

The 2023 diagnostic report further emphasised these challenges, noting that *"some candidates confused the height (2.5 cm) of the post cap with the perpendicular height (7.86 cm)" (DBE, 2023; p. 208(g))*. Additionally, the report stated that: *"most candidates could not change the subject of the formula to calculate the volume of ice" (DBE, 2023; p. 210(c))*, and *"most candidates did not divide 313.67 by 24 hours to determine the number of days and hours to find the arrival date and time" (DBE, 2023; p. 208(g))*.

These examples point to a pattern of contextual disconnection—learners perform mathematical operations without considering the practical meaning or physical quantities involved.

Interviews with teachers during this study provided further insights. Mr Quenric observed that

> *"another error is in estimating Measurement, especially when they're asked to approximate the size of something. They often overestimate or underestimate, and I've noticed that it's because they don't have enough practice with real-life objects"*.

Mr Quenric also noted that

> *"when working with bar scales, learners use the scale as is without converting to real life before using it. They then use the map scale with the real distance without any conversions"*.

Ms Zyphron added that

"learners struggle with real-life application" and *"lack basic skills application with regard to time and basic formulas"*.

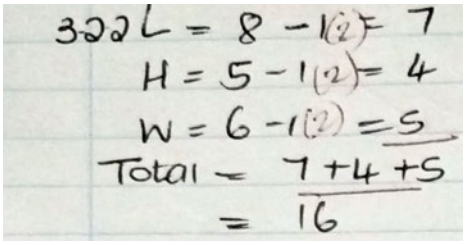
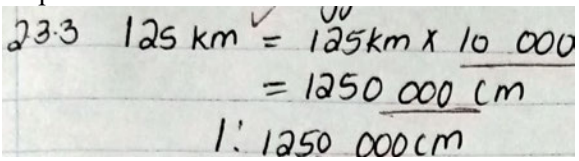
These observations align with the findings reported in diagnostic reports, highlighting a disconnect between theoretical knowledge and practical application. These reflections suggest that application errors emerge from limited experiential grounding—learners seldom engage with measurement through hands-on or contextualised learning experiences.

Learners' exam scripts confirmed this disconnect. Many responses showed confusion about scaling, as some learners used the map scale directly without converting to actual distances. Others failed to apply formulas in context, producing calculations unrelated to the problem scenario. The examples in Figure 19 illustrate these tendencies: learners misapplied formulas to real-world problems and confused symbolic and physical scales. Such errors demonstrate that even when procedural knowledge is intact, learners struggle to identify when and how to use it—a clear indication of deficient conditional knowledge (knowing when to apply a rule) and contextual reasoning (knowing why it applies).

The questions used to elicit responses are included in the question paper (Appendix J) to support the interpretation of learners' responses.

Figure 19

Application errors identified in learners' scripts

Applying mathematical calculations to real-life problems	Misunderstanding scale measurements from maps to real distances
 (Transcription:) (3.2.2) $L = 8 - 1 = 7$ $H = 5 - 1 = 4$ $W = 6 - 1 = 5$ $Total = 7 + 4 + 5$ $= 16$	 (Transcription:) (2.3.3) $125\ km = 125km \times 10\ 000$ $= 1250\ 000cm$ $= 1: 1250\ 000\ cm$

Furthermore, the prevalence of interpretation and application errors suggests that learners' inability to differentiate, interpret, and apply or contextualise problems indicates a lack of

development of measurement concepts. This finding aligns with the existing literature. For instance, Khalid and Pulungan (2019) reported that a lack of understanding of problem contexts and formula concepts contributes to errors. The mentioned study corroborate the findings of the diagnostic reports and interviews with teachers in this study, emphasising the need for targeted interventions to address learners' misconceptions. The findings also resonate with Verdejo et al. (2021), who found that errors in Measurement often occurred during the simplification and validation phases of problem-solving. This was evident in learners' inability to contextualise measurement tasks and apply formulas correctly. Additionally, the unit conversion and scaling challenges observed in this study align with the findings of Huang et al. (2020), who identified syntactic and lexical errors as common barriers to understanding measurement concepts.

The findings of this study extend previous research by highlighting the dual challenge learners face contextualising measurement tasks and applying formulas, as shown in Figure 19, where misreading the problem (interpretation) often precipitates misapplication of procedures (application), creating a compounding effect that undermines performance, which is not explicitly addressed in earlier studies.

Furthermore, the recurring confusion between concepts such as area and perimeter can be interpreted through the lens of constructivist theory. From a constructivist perspective, learners approach new mathematical concepts using their existing cognitive structures or schemas (Piaget, 1977). When learners attempt to apply familiar procedures, such as multiplying side lengths, to problems involving perimeter, they may be engaging in a process of assimilation, where new information is interpreted through existing but inappropriate conceptual frameworks. In this case, learners appear to assimilate the concept of perimeter into their existing understanding of area calculations. Such misconceptions highlight the need for instructional strategies that encourage conceptual restructuring, or accommodation, where learners modify their existing schemas to align with correct mathematical relationships.

5.8 Chapter summary

This chapter has explored common errors and misconceptions in the Measurement topic of Mathematical Literacy, addressing the first research sub-question. The findings were presented through four key themes: procedural, computational, conceptual, and interpretation and application challenges. Learners frequently made procedural errors, such as misapplying

formulas, incorrectly converting units, and misunderstanding geometric calculations. These errors often stemmed from deeper misconceptions, such as confusing perimeter with area or misusing unit conversion factors. Practical tasks, like map reading, further highlighted these issues, while over-reliance on calculators led to procedural blindness. The findings align with the existing literature and extend it with procedural errors in applied tasks—such as practical measurement tasks—such as map reading and real-world calculations—as well as abstract tasks.

Learners' conceptual errors revealed fundamental misunderstandings, including confusing radius and diameter, misapplying area and volume formulas, and struggling with proportional reasoning. Learners often substituted incorrect values into formulas or failed to simplify ratios; interviews with teachers confirmed these persistent issues. Additionally, learners struggled to define and contextualise mathematical concepts—such as 'floor plan'—indicating a gap in conceptual understanding. This study extends prior research by emphasising the intersection of Measurement and proportional reasoning and the importance of contextualisation in addressing conceptual errors.

Interpretation and application issues further compounded learners' challenges. Interpretation errors included misreading questions and failing to contextualise problems, while application errors involved misapplying formulas and misunderstanding scale conversions. Diagnostic reports and teacher interviews highlighted recurring issues, such as misapplying fractions and failing to verify answers, underscoring a disconnect between theoretical knowledge and practical application. These findings align with existing literature but extend it by highlighting the dual challenge learners face contextualising measurement tasks and applying formulas, which is not explicitly addressed in earlier studies.

The next chapter presents the findings related to the second research sub-question: 'How do Mathematical Literacy teachers engage with learners' misconceptions and errors in Measurement?' This builds upon the findings presented in this chapter, offering insights into teaching strategies and pedagogical responses to learner misconceptions in ML.

CHAPTER 6: FINDINGS ON TEACHERS' ENGAGEMENT WITH LEARNERS' MISCONCEPTIONS AND ERRORS IN MEASUREMENT

6.1 Introduction

The previous chapter presented the findings on the first research sub-question, which concerned the misconceptions and errors that learners make in the topic of Measurement. This chapter presents the findings on the second research sub-question: 'How do Mathematical Literacy teachers engage with learners' misconceptions and errors in Measurement?' The presentation of results draws on data collected from observing six teachers while teaching lessons on the topic of Measurement in Mathematical Literacy (ML), supported by follow-up interviews with teachers and analysis of samples of learners' work. The chapter relates the findings derived in this study to the relevant literature discussed in Chapter 2.

Lesson observation was used to explore how Mathematical Literacy teachers engaged with learners' misconceptions and errors in Measurement. Specifically, the observations examined how teachers applied their content knowledge when teaching Measurement topics, the instructional strategies they employed, and the ways in which they identified and addressed learners' misconceptions and errors. The focus was on understanding how teachers diagnosed learners' difficulties related to Measurement and what interventions they used to support learners in overcoming these challenges. Each teacher was observed over two periods (1 hour each) on two different days.

This chapter presents an analysis and discussion of the lesson observations supported by interviews with teachers and analysis of learners' exercise books, detail teachers' instructional approaches, engagement with learners, and strategies for addressing errors in Measurement. The findings are organised into seven themes. First, classroom organisation is discussed, followed by how lessons are introduced and prior knowledge activated. The chapter then explores teachers' identification of learner misconceptions and errors, detailing common mistakes by learners and teachers' diagnostic techniques. Next, the chapter discusses teachers' remedial strategies, such as error correction, use of visual aids, and feedback mechanisms. Learner engagement and peer interaction are discussed, followed by teaching strategies, including scaffolding and instructional aids. Finally, teachers' assessment and feedback practices are analysed.

6.2 Identification of themes

The themes presented in this chapter were pre-determined themes from the observation protocol used for data collected during lesson observations, following Braun and Clarke's (2006) six-phase framework. Initially, segments of data from classroom observations, interviews, and documents were assigned initial codes that captured key actions, practices, or explanations related to learners' misconceptions in Measurement. These codes were then grouped into pattern codes, allowing recurring instructional practices and challenges to be identified across the dataset. Through an iterative process of comparison and refinement, these pattern codes were organised into broader analytical themes, which are presented in Tables 8 and 9. The observation themes were informed deductively by the lesson observation protocol, while the interview themes emerged inductively from teachers' reflections during the analysis process.

Seven pre-determined themes from the observation protocol were used for data collected during lesson observations, as shown in Table 9.

Table 9

Themes pre-determined for lesson observations

1. Classroom Organisation and Learning Environment
2. Lesson Introduction and Activation of Prior Knowledge
3. Identification of Misconceptions and Errors
4. Teacher's Remedial Strategies and Instructional Adjustments
5. Learner Engagement and Peer Interaction
6. Teaching Strategies and Pedagogical Approaches
7. Assessment and Feedback

These themes provide a structured way to analyse the data collected from classroom observations augmented by interviews and content analysis, aligning with the study's focus on how ML teachers engage with learners' misconceptions and errors in Measurement. The findings related to each theme are presented in detail in the sections that follow.

6.3 Theme 1: Classroom organisation and learning environment

This section analyses the classroom organisation and learning environments of six ML teachers, examining various classroom configurations and incorporating insights from interviews with teachers to illuminate the pedagogical rationale driving their choices.

6.3.1 A structured and resource-rich environment

Ms Zyphron's classroom was structured to foster peer collaboration and maximise efficient learning. The class consisted of 15 learners, six males and nine females of mixed ability, seated in two columns of double desks, allowing sufficient space for movement. Advanced learners were strategically paired with their struggling peers to encourage collaborative learning and peer support. Ms Zyphron positioned herself at the back of the classroom, a deliberate choice that enabled her to monitor learners effectively, maintain engagement, and provide discreet assistance when necessary.

The classroom environment was well-maintained and equipped with various teaching tools, including a projector, smartboard, whiteboard, and a range of measurement tools such as rulers, measuring tapes, and geometric shapes. The walls prominently displayed the Annual Teaching Plan (ATP) for ML, ensuring learners had a structured overview of their curriculum. Learners were also provided with abridged work schedules to track daily topics, activities, and assessment dates. A unique feature of the way the school structured teaching and learning was that learners rotated between classes while teachers remained stationed in their subject-specific classrooms. This arrangement allowed Ms Zyphron to remain in a resource-rich environment, ensuring that instructional materials were consistently available for effective lesson delivery.

In a follow-up interview regarding her classroom arrangement, Mrs Zyphron explained:

> *"I pair mixed-ability learners together because it helps them learn from each other. It's all about teamwork and making sure everyone gets the support they need. Learners sit in columns because it helps them focus, especially when they're working on individual tasks like solving measurement problems, and it makes it easier for me to move around and help anyone who's stuck."*

Ms Zyphron's classroom blended structure and collaboration, aiming to enhance active learning. She paired advanced and struggling learners to encourage peer support in line with Vygotsky's zone of proximal development. By positioning herself at the back of the room, she supported a student-centered approach, facilitating observation and guidance rather than

traditional instruction. The incorporation of technology and clear curriculum outlines promoted learner autonomy through accessibility. Her focus on teamwork highlighted a constructivist view of learning as a social process, driven by interaction and collective problem-solving.

6.3.2 Encouraging peer interaction

In contrast to Ms Zyphron's structured environment, Mr Vexora used a more flexible, discussion-oriented seating arrangement. His class comprised 11 learners, three males and eight females, seated at three large tables arranged in a rectangular formation. This setup allowed groups of at least four learners to sit together, fostering group discussions and collaborative problem-solving. The teacher sat at the left corner of the chalkboard, maintaining a clear view of all learners.

At this school, learners remained in the same classroom while their teachers moved between different classes. This structure required Mr Vexora to adapt his teaching methods based on the learners of each class. Unlike Ms Zyphron's classroom, the classroom did not have ML-related materials on the walls. Mr Veroxa provided learners with printed notes and activities to ensure they had access to necessary resources.

Explaining his rationale for the classroom arrangement, Mr Vexora stated:

> *"Some learners are lazy and don't want to work, and they become disruptive when struggling, so I prefer that they sit in groups and work together to make sure that they are motivated when they see others being busy, and they can ask the others in the group for help."*

Mr Vexora's classroom exemplified a flexible, socially-driven learning environment focused on interaction and collective problem-solving. The rectangular table arrangement facilitated open dialogue and group participation, reflecting constructivist principles. Although there were no visible Mathematical Literacy materials, printed notes enhanced resource accessibility. His observation that group work aids "*lazy*" or struggling learners highlights the importance of social dynamics in motivation and accountability. Overall, the classroom design and pedagogical choices prioritized collaboration as a key factor in maintaining learners' engagement and comprehension.

6.3.3 The challenge of overcrowding

Mr Quenric's class experienced significant spatial constraints, with 48 learners (19 males and 29 females) crowded into a space not designed for such a large cohort. The seating arrangement

was neither fixed nor structured, as learners sat on single chairs at double desks. Due to the shortage of desks, some desks designed for two learners were occupied by four or five, limiting mobility and restricting the teacher's access to all areas of the classroom. The classroom walls were bare and devoid of instructional materials, while essential resources such as textbooks and measurement tools were also not sufficient. The teacher relied on writing notes on the board, as no printed copies were available for learners. In an interview, Mr Quenric reflected on the constraints imposed by overcrowding:

> *"In this school, we have had a problem of overcrowding since I joined. With 48 learners in a space that's not designed to accommodate such a large number, it's extremely difficult to create a comfortable and functional seating plan."*

Mr Quenric's classroom demonstrated the negative impact of overcrowding on education, with 48 students in a small space limiting mobility, structure, and resources. This resulted in less learner engagement and teacher interaction, with a heavy reliance on board work and a shortage of visual aids and instructional materials, further hindering participation and comprehension. His observations reveal a wider systemic issue in resource-limited environments, where overcrowding impedes the development of the supportive, learner-centered environments crucial for effective engagement in Mathematical Literacy.

6.3.4 Fostering independent learning

Ms Tarkis's class consisted of 22 learners, seven males and 14 females. At this school, learners remained in the same classroom, while Ms. Tarkis rotated between different classrooms. Learners were seated in four columns of single desks; a deliberate arrangement aimed at promoting individual accountability. This structure allowed for easy movement and visibility, ensuring the teacher could closely monitor each learner's progress.

Despite a relatively organised setup, the classroom lacked instructional materials on the walls, except for a single poster displaying the levels of misconduct and the school's code of conduct. Learners could access exercise books and printed activities but lacked textbooks or measurement materials for independent reference. Although Ms rotated between classrooms, and thus did not control the arrangement of this particular classroom, she justified the seating arrangement:

> *"These learners will write an examination sitting alone, so I am trying to create the same environment as early as possible and reduce distractions. They make a lot of noise*

when sitting with another person. Also, I want to see who is struggling and make them independent and accountable without relying on others. But when it's time to do corrections, I do allow them to help each other"

Ms Tarkis's classroom emphasized independence and accountability, utilizing single desks to encourage focus and personal responsibility. This approach reflects behaviourist principles, prioritizing individual performance over collaborative learning. While her mobility and printed activities showed adaptability, the lack of visual aids and measurement tools limited exploratory engagement. Her seating rationale supported self-regulated learning but potentially hindered collaborative interactions vital for deeper understanding in Mathematical Literacy.

6.3.5 A collaborative learning environment

Ms Luneth conducted her lessons in a mathematics laboratory, where her 29 learners, 15 males and 14 females, were seated in groups of five around round tables, fostering collaboration. Unlike the other classrooms, her classroom walls were covered with charts related to both Pure Mathematics (PM) and ML, creating an engaging and visually stimulating learning environment. The availability of essential resources such as textbooks, calculators, and measurement materials enhanced learners' engagement. Ms. Luneth explained that the classroom had been set up this way before she arrived and she was not able to change the arrangement; however, she found that the arrangement supported teaching and learning:

"I found it like this: the tables were round and screwed to the floor. But I like it. And it works to my advantage because the learners work well together in groups and assist each other, even when I am not in the classroom."

Ms. Luneth's classroom facilitated collaborative and participatory learning through a round-table setup that promoted interaction and problem-solving, aligning with constructivist pedagogy. The presence of various learning resources enhanced conceptual understanding. Her understanding of peer-assisted learning indicated a culture of shared responsibility, showcasing effective social constructivist principles in Mathematical Literacy instruction.

6.3.6 Resource constraints and overcrowding

Like Mr Quenric, Mr Orvex faced the challenge of overcrowding. A mobile container, which was in good condition, served as a classroom. With 44 learners, 21 males and 23 females, the space was too small to enable effective teaching and learning. The seating arrangement was unstructured, with limited movement due to the densely packed double-desk seating. A

shortage of instructional materials further exacerbated the challenges. Learners had limited access to textbooks, and the teacher was compelled to write extensive notes on the board due to a lack of printing resources. Discussing the difficulties, Mr Orvex stated:

> *"This year has been particularly challenging because I have a lot of learners and three classes—totalling 123. Many learners did not perform well in Pure Mathematics last year, and the principal advised their parents to switch them to Mathematical Literacy, leading to a significant rise in enrolment. Even with additional containers, space is still a major issue."*

Mr. Orvex's classroom illustrates how overcrowding and resource shortages impact teaching and learning. With 44 learners in a small mobile container, mobility and individual support were significantly hindered. The absence of textbooks and printing resources led to a reliance on board work, limiting learner engagement. His observations highlight systemic issues, as increased enrolment, especially from students redirected from Pure Mathematics, exacerbated pressures on already scarce resources. Such an environment restricts the use of interactive, constructivist teaching methods, reducing Mathematical Literacy instruction to a predominantly teacher-led approach.

These findings on the organisation and learning environment of these six classrooms align with the existing literature on the role of classroom organisation and learning environments in addressing learners' misconceptions. The significant variations in classroom organisation result in different possibilities for how misconceptions and errors were identified and addressed. For instance, Ms Zyphron's well-structured and resource-rich environment facilitated peer collaboration, which is critical for addressing misconceptions through social interaction and peer support, where learners feel comfortable sharing mistakes with their peers (La Hadi & Dedyerianto, 2020). Her strategic pairing of advanced learners with struggling peers aligns with research suggesting that peer-assisted learning can effectively address misconceptions by allowing learners to co-construct knowledge (Walker et al., 2021).

In contrast, Mr Vexora's flexible, discussion-oriented seating arrangement encouraged peer interaction, which is essential for identifying and correcting misconceptions through dialogue and collaborative problem-solving (Hidayat et al., 2023). However, the lack of ML-related materials on the walls may have limited learners' exposure to visual aids that could reinforce correct conceptual understanding. Similarly, Ms Luneth's collaborative learning environment in the mathematics laboratory provided an ideal setting for addressing misconceptions through

group work and hands-on activities, which are central to constructivist approaches (Johnston, 2020).

On the other hand, teachers like Mr Quenric and Mr Orvex faced significant challenges due to overcrowding and resource constraints, which hindered their ability to address misconceptions effectively. Overcrowding limited their mobility and access to learners, while the lack of instructional materials restricted learners' opportunities to engage meaningfully with Measurement concepts. Wright et al. (2019) found that smaller classes fostered active engagement, while Blatchford and Russell (2019) found that class size did not directly impact learners' achievement how the teacher manages and teaches learners. The findings in this study highlight the importance of both adequate resources and manageable class sizes for addressing learner misconceptions.

The findings also disagree with the existing literature. For instance, Pepkolaj et al. (2020) found the potential drawbacks of collaborative learning in high school mathematics. They found that while it enhances social interaction and knowledge acquisition, it can lead to issues such as group assessment challenges and time inefficiency. This study highlighted an example of a traditional, teacher-centred classroom arrangement in Ms Tarkis's classroom, where learners worked independently during lessons in an exam-style seating format but were allowed to collaborate with peers during correction activities.

6.3.7 Summary of classroom organisation and learning environments

The analysis of the six classrooms revealed substantial variation in how learning environments were organised and how these organisational structures shaped opportunities for addressing learners' misconceptions in Mathematical Literacy. The findings demonstrate that classroom organisation, availability of resources, and class size influenced the extent to which teachers were able to facilitate interaction, monitor learners' work, and respond to misconceptions during instruction.

In resource-rich and structured environments, the availability of instructional materials and collaborative seating arrangements created opportunities for peer interaction and active engagement with Measurement tasks. These environments supported constructivist forms of learning in which misconceptions could be identified and addressed through dialogue, peer assistance, and guided teacher intervention.

In contrast, classrooms characterised by overcrowding and limited resources, constrained teachers' ability to move around the classroom, observe learners' work closely, and provide individual support. These conditions often resulted in teacher-centred instruction and a greater reliance on board work, limiting opportunities for learners to explore Measurement concepts collaboratively.

Other classrooms demonstrated alternative pedagogical priorities. For instance, discussion-oriented seating arrangement emphasised social interaction and collaborative problem-solving, while examination-style seating promoted individual accountability and independent work. These contrasting approaches highlight how teachers balance collaborative learning with the demands of assessment preparation in Mathematical Literacy classrooms.

The findings suggest that classroom organisation and the learning environment play a significant role in shaping how teachers identify and address learner misconceptions. Environments that enable movement, interaction, and access to instructional resources appear to support more effective engagement with learners' errors, whereas overcrowded or resource-limited contexts restrict opportunities for diagnostic teaching and conceptual development.

The following section presents and analyses the ways teachers accessed prior knowledge and introduced new lessons on Measurement.

6.4 Theme 2: Lesson introduction and activation of prior knowledge

Effective lesson introductions play a critical role in establishing conceptual continuity and situating new learning within learners' existing knowledge frameworks (Guldona, 2025). Activation of prior knowledge involves using learners' existing understanding to enhance comprehension by making connections, predicting content, and integrating new information (Hattan et al., 2024). This section explores how teachers connected prior knowledge and introduced new Measurement lessons in Mathematical Literacy. Seven distinct but interrelated approaches were observed across classrooms: explicitly recapping content taught in previous grades to reinforce continuity in learning; adopting hands-on and baseline assessment and targeted instructional activities; employing review-based discussions and real-life scenarios; facilitating correction of previous work and interactive questioning to promote reinforcement of learning; and recalling foundational distinctions while using past examination questions to consolidate understanding of key Measurement concepts.

6.4.1 Recapping content taught in previous grades to activate prior learning

Ms Zyphron introduced the topic of Measurement to her Grade 12 learners and demonstrated an explicit approach to linking prior knowledge with new learning. She initiated the lesson by recapping content taught in the previous grades, specifically Grades 10 and 11. She reminded learners of the 'King Henry' song, a mnemonic device learner had been taught in previous grades to aid them with conversions. During the lesson, she said:

> *Do you remember the King Henry song we used last year for conversions—and also in Grade 10? Yeeees…. That is what we will be doing again this year. The only difference is that in this grade, we will be converting into bigger projects and complex projects in both familiar and unfamiliar contexts.*

This approach activated learners' prior knowledge, strengthened the continuity of learning, and provided a contextual foundation for the day's lesson.

6.4.2 Baseline assessment and targeted instruction

Ms Zyphron demonstrated a structured and evidence-informed approach to lesson introduction by administering a baseline assessment test the day before. The purpose of this pre-lesson assessment was to gauge learners' prior knowledge, identify misconceptions, and determine their readiness to engage with new Measurement content. Ms Zyphron used the information gathered from the baseline test to design targeted instructional strategies that directly addressed specific misconceptions and reinforced conceptual understanding. By explicitly connecting new material to learners' existing understanding—such as reviewing conversion methods using the 'King Henry' mnemonic—Ms Zyphron ensured that instruction built upon familiar concepts. This approach exemplifies the value of diagnostic and targeted teaching practices in enhancing both immediate comprehension and long-term retention, particularly within mathematics education where foundational knowledge is cumulative.

Similarly, Mr Vexora employed a diagnostic approach to assess and activate prior knowledge at the start of his lesson. He conducted a brief diagnostic activity designed to gauge learners' understanding of *Area* before introducing new instructional content. This formative check served a dual purpose: it allowed him to identify residual misconceptions from previous lessons on *Perimeter* and provided a basis for adjusting his explanations to address specific conceptual gaps. By embedding this diagnostic task in the lesson introduction, Mr Vexora ensured that his instruction was responsive to learners' current cognitive readiness. His approach complemented that of Ms Zyphron in demonstrating how strategic pre-lesson evaluation and

adaptation of instruction foster conceptual continuity and support deeper learning in Mathematical Literacy.

6.4.3 Hands-on activity to introduce a topic

To introduce the topic of Measurement with a focus on conversions, Ms Zyphron employed a hands-on activity. She provided learners with measuring tapes and encouraged them to measure one another, subsequently requiring them to convert the obtained values into different units, including kilo, hector, deca, meter, deci, centi, and milli. This activity effectively engaged learners in the practical application of previously acquired knowledge. Like Ms Zyphron, Ms Luneth's lesson introduction diverged from the recap-focused approaches observed in other classrooms. Rather than reflecting on prior lessons, she directly introduced the topic of measuring mass (weight). She employed an engaging and practical strategy, using a digital scale and measuring tape to facilitate an activity in which learners calculated their Body Mass Index (BMI). This hands-on method allowed learners to apply Measurement concepts in a real-world context. To activate prior knowledge, she provided an activity requiring learners to compute their BMI, ensuring that foundational concepts were reinforced before expanding on the topic.

6.4.4 Review-based discussion, real-life scenario presentation and diagnostic activity

Similarly, Mr Vexora structured his lesson to integrate prior learning through a review-based discussion. He began by revisiting key concepts from the previous lesson on Perimeter, facilitating a dialogue in which learners articulated their understanding of Perimeter and contrasted it with the new topic of Area. To further contextualise the lesson, he presented a real-life scenario in which learners estimated the dimensions of a table and calculated its Area, comparing it with the Perimeter calculations from the previous day. This method reinforced the interconnectedness of mathematical concepts and provided a tangible application of theoretical knowledge.

6.4.5 Facilitating corrections of previous work and interactive questioning

Mr Quenric adopted a structured, yet somewhat limited, approach to lesson introduction. He initiated the session by facilitating corrections of the previous lesson's activity on Perimeter, ensuring that learners identified and rectified their errors. However, his introduction of the new topic of Area was minimal, focusing primarily on explaining its distinction from Perimeter without engaging learners in a deeper exploration of prior knowledge. Notably, there was no

formal assessment of prior misconceptions, which might have limited opportunities to address learners' conceptual difficulties before progressing with the lesson.

6.4.6 Facilitating corrections of previous work and interactive questioning

Similar to Mr Quenric's approach, Mr Orvex structured his lesson around reinforcing previously covered material rather than introducing new content and linking it to prior knowledge. Mr Orvex began the session by conducting corrections of the last lesson's activity, which encompassed various Measurement concepts, including Area, Perimeter, Volume, and Surface Area. While this approach ensured that learners addressed their mistakes and clarified misunderstandings, there was no dedicated introduction of new content during the observed lesson, as the purpose of this lesson and lesson time was dedicated to remediation and reconstruction of knowledge to ensure learners had established a solid foundation before moving to new content. To assess learners' comprehension and identify misconceptions, Mr Orvex engaged them in interactive questioning, prompting them to explain problem-solving steps and collaborate to work out solutions. The teacher played a guiding role, providing final validation of the correctness of responses and identifying conceptual errors.

6.4.7 Recalling foundational distinctions and use of previous exam question papers

In Ms Tarkis's classroom, the lesson introduction similarly followed a recap-based approach. She briefly reviewed the differences between Area and Perimeter, ensuring learners recalled foundational distinctions. To further strengthen prior knowledge activation, she incorporated questions from previous examination papers on the Area, providing learners with structured activities that mirrored assessment conditions. However, despite this structured approach, there was no explicit initial assessment of learners' prior misconceptions, which might have provided deeper insight into potential learning gaps.

These findings showed that while some teachers actively assessed and engaged learners' prior knowledge to address their misconceptions, others assumed that learners had retained previous learning of concepts. In some cases, teachers' lack of systematic assessment of prior knowledge suggests a missed opportunity for identifying and correcting deeply rooted misconceptions in Measurement. Existing literature underscores the importance of prior knowledge activation and formative assessment in addressing misconceptions in Mathematics education (Hattan et al., 2024). Research by Morales Brignac (2022) and Rashid et al. (2021) suggests that misconceptions often stem from inadequate conceptual grounding in foundational concepts

such as unit conversion and spatial reasoning. As observed in Ms Zyphron and Mr Vexora's lessons, the practice of measuring and converting values aligns with recommendations from literature advocating for hands-on, inquiry-based approaches (Hattan et al., 2024).

Conversely, the lack of explicit diagnostic assessment by some of the teachers reflects challenges identified in previous studies. Moru and Mathunya (2022) found that many teachers assume learners retain prior knowledge, leading to the persistence of uncorrected errors. The findings from Ms Tarkis and Mr Quenric's lessons illustrate this issue, as learners were expected to engage with new Measurement content without a structured review of misconceptions. This agrees with studies suggesting that Mathematics teachers sometimes prioritise procedural fluency over conceptual understanding (Yasseen et al., 2020).

Ms Zyphron's use of the 'King Henry' song across grades exemplifies longitudinal continuity, extending to the literature on spiral curricula. The sustained use of mnemonics across years provides novelty on how such tools aid retention, contributing to discussions on memory-enhancing strategies in mathematics education. Additionally, Ms Tarkis's use of past exam questions to activate prior knowledge connects to the literature on assessment-as-learning. This approach prepares learners for exams and reinforces content retention, offering insights into how high-stakes testing environments can be leveraged for meaningful learning.

The following theme (Theme 3) focuses on learner's errors and misconceptions, reporting techniques used by teachers to *identify* learners' errors and misconceptions. The theme that follows that (Theme 4) presents and analyses strategies teachers employ to *address* learners' errors and misconceptions. The decision to present these two aspects separately is both methodological and analytical. This structure ensures a logical and progressive flow of analysis that mirrors the pedagogical process observed in classroom practice.

6.5 Theme 3: Identification of misconceptions

Identifying learners' misconceptions is a prerequisite for developing effective remedial strategies. As highlighted by Booth et al. (2017) and Rashid et al. (2021), teachers can only respond meaningfully to learners' difficulties once they have accurately diagnosed the nature and source of those misconceptions. This theme provides the necessary foundation by detailing how teachers recognise and interpret learners' conceptual and procedural errors. This diagnostic phase is crucial for understanding the underlying challenges that impede learning.

The section is organised according to the six participating teachers, with each sub-section detailing specific classroom contexts and examples of the misconceptions observed. These are discussed in the following order: Ms Zyphron's lesson on challenges with unit conversions; Mr Vexora's lesson on misconceptions about Area and Perimeter; Mr Quenric's lesson on unit conversion in Perimeter calculations; Ms Tarkis's lesson on confusion between Area and Perimeter; Ms Luneth's lesson on errors in BMI calculations; and Mr Orvex's lesson on the misapplication of formulas in Surface Area calculations.

6.5.1 Ms Zyphron's lesson: Challenges with unit conversions

In Ms Zyphron's class, issues related to unit conversions emerged as a significant challenge. Learners struggled particularly when required to recall the appropriate conversion factor and determine whether to multiply or divide. A notable difficulty was observed when learners attempted to convert grams to tons, as this unit had not been explicitly introduced within the sequence of metric conversions covered in prior lessons. The following problem was given:

Convert 8000 g to kilograms and metric tons.

The expected correct solution follows these steps:

- Since 1 kg = 1000 g, then 8000 g ÷ 1000 = 8 kg.
- Since 1 ton = 1000 kg, then 8 kg ÷ 1000 = 0.008 tons.

However, some learners demonstrated errors in their responses. One learner made a computational error, incorrectly dividing by 100 instead of 1000, resulting in:

8000 ÷ 100 = 80 kg.

Another learner exhibited a conceptual misconception by assuming that 100 grams make 1 kilogram, leading to the incorrect response:

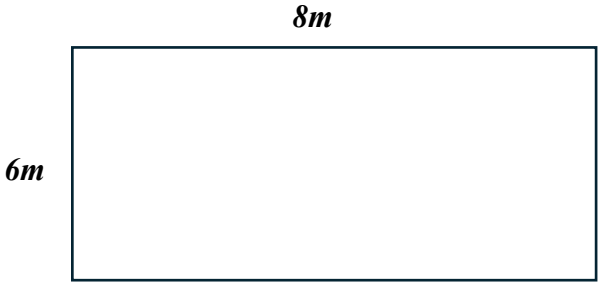
8000 g = 80 kg = 0.8 t.

Ms Zyphron employed scaffolded, step-by-step modelling of the correct procedures, enabling her to observe where learners deviated from the expected logical sequence. For example, if learners skipped steps or misapplied unit prefixes (e.g., confusing 'centi' with 'milli'), their confusion became visible during guided practice. While circulating among groups, Mrs Zyphron listened to learners' discussions, observed problem-solving strategies, and noted recurring mistakes (e.g., incorrect decimal placement in conversions). Collaborative tasks often

reveal misconceptions that may remain hidden during individual work, as learners are required to articulate their reasoning and engage in peer dialogue. Mrs. Zyphron required groups to articulate their reasoning when they presented their solutions. For example, a learner might say, 'We moved the decimal three places because kilo means 1,000,' revealing a rote application without understanding metric prefixes.

6.5.2 Mr Vexora's lesson: Misconceptions about area and perimeter

In Mr Vexora's class, learners displayed notable difficulty differentiating *area* and *perimeter*, particularly in applying the correct formulas and interpreting the corresponding units. During the observed lesson, the teacher presented a diagram of a rectangle on the board with the dimensions 8m x 6m as follows:



Learners were asked to calculate both the *area* and *perimeter* of the garden and to state their answers with appropriate units. While some learners arrived at the correct responses, several misapplied the formulas.

One learner, for instance, multiplied all sides together and wrote:

$$Area = 8 \times 6 \times 2 = 96\ m^2$$

When asked to explain their reasoning, the learner replied, "*I multiplied all the sides to get the outside of the garden.*" This response revealed conceptual confusion between the formulas for area and perimeter. The learner appeared to recall that the formula for perimeter involves a multiplication by two, $P = 2(l + w)$, but incorrectly applied this logic to the area formula. Instead of adding the length and width before doubling, the learner multiplied all three numbers together, blending elements of both formulas. This indicates partial procedural recall without conceptual understanding of the relationship between length, width, and boundary measurement.

Other learners also demonstrated confusion in their use of measurement units, providing answers in 'm³' instead of 'm²' and showing uncertainty between linear, square, and cubic dimensions. The teacher actively identified these misconceptions through classroom discussions, open-ended questioning, and quick problem-solving exercises. By encouraging learners to explain their reasoning, Mr Vexora was able to pinpoint and address their misunderstandings effectively.

6.5.3 Mr Quenric's lesson: Unit conversion in perimeter calculations

A similar challenge with unit conversions was observed in Mr Quenric's class, particularly when learners were tasked with calculating the perimeter of a rectangular garden with dimensions given in mixed units, as follows:

> *A rectangular garden has a length of 2.5 meters and a width of 150 centimetres. Calculate the perimeter of the garden.*

One learner incorrectly added the values without converting the units first:

> *Perimeter = 2(2.5 + 150) = 2(152.5) = 305 m.*

Here, the learner failed to convert 150 cm to meters before performing the calculation. The correct process should have been:

> *150 cm ÷ 100 = 1.5 m.*

Thus, the accurate perimeter calculation is:

> *P = 2(2.5 + 1.5) = 2(4) = 8 m.*

To identify these errors, Mr Quenric employed probing questions during correction sessions, prompting learners to reflect on their approach before guiding them toward the correct solution.

6.5.4 Ms Tarkis's lesson: Confusion between area and perimeter

During a lesson on area and perimeter, Ms Tarkis observed that learners frequently applied the incorrect formula to solve problems. For instance, when given the following problem:

> *A rectangular playground has a length of 10 meters and a width of 5 meters. Find the perimeter and area.*

some learners mistakenly calculated the perimeter as follows:

> *P = 10 × 5 = 50 meters,*

instead of the correct formula:

P = 2(10 + 5) = 30 meters.

Similarly, when asked to determine the area, some learners applied the perimeter formula:

A = 2(10 + 5) = 30 m²,

instead of the correct approach:

A = 10 × 5 = 50 m².

Ms Tarkis employed questioning techniques to identify these misconceptions, prompting learners to analyse their responses and reflect on the difference between linear and square measurements.

6.5.5 Ms. Luneth's lesson: Errors in BMI calculations

In Ms Luneth's class, learners encountered difficulties when applying the formula for calculating Body Mass Index (BMI). Learners were given the following task:

A learner weighs 60 kg and has a height of 1.5 meters. Calculate their BMI using the formula:

BMI = Weight (kg) / (Height (m)²)

One learner gave an incorrect response, failing to square the height before division, as follows:

BMI = 60 ÷ 1.5 = 40.

The correct calculation is:

BMI = 60 / (1.5 × 1.5) = 26.67.

Ms. Luneth leveraged peer learning to identify misconceptions. For example, when one learner said, "But doesn't m² mean the final answer is in square meter?" another learner responded, "No, it means that you must square the height of the person".

6.5.6 Mr Orvex's lesson: Misapplication of formulas in surface area calculations

In Mr Orvex's class, he identified that learners displayed errors when applying the formula for surface area. Learners were given the following problem:

A rectangular box has dimensions length = 5 cm, width = 3 cm, and height = 4 cm. Calculate the surface area using the formula:

$$SA = 2(lw + lh + wh)$$

One learner copied the formula correctly but misapplied it in their calculations:

$$SA = 2(5 \times 3 + 4 + 3) = 2(15 + 4 + 3) = 2(22) = 44\ cm^2.$$

Here, the learner failed to multiply all terms before summing. The correct approach should have been:

$$SA = 2(5 \times 3 + 5 \times 4 + 4 \times 3) = 2(15 + 20 + 12) = 2(47) = 94\ cm^2.$$

Mr Orvex identified these misconceptions during test and exam marking and addressed them collectively by reviewing common errors from previous years and Department of Basic Education (DBE) diagnostic reports.

The observed errors, such as confusing metric prefixes (e.g., grams vs kilograms), misapplying conversion factors, and conflating area with perimeter, are well-documented in prior studies (Rashid et al., 2021; Mbonambi & Bansilal, 2014; Tastepe & Yanik, 2023). The teachers' techniques, such as scaffolding (Ms Zyphron), think-aloud (Mr Vexora), and peer discussions (Ms Luneth), are supported by the literature. Mustafa et al. (2021) found that guided, incremental learning exposes misconceptions and makes it easier to see where learners' thinking has gone wrong— allowing the teacher to identify and correct misconceptions early . Research on cooperative learning highlights how peer dialogue reveals hidden misunderstandings (Chen, 2020). Additionally, the feedback model underscores the importance of probing questions to uncover reasoning gaps (Nemt-Allah & Darwesh, 2024).

While prior studies such as Pepkolaj et al.'s (2020) discuss the benefits of group work, this study extends the literature by demonstrating real-time error identification in collaborative settings where teachers actively monitor group discussions to detect misconceptions (e.g., Ms Zyphron listening for incorrect decimal shifts). This real-time formative assessment is under-researched in Science, technology, engineering, and mathematics (STEM) contexts. The recurring errors in unit conversions (Mr Quenric's class) and BMI calculations (Ms Luneth's class) suggest that some misconceptions persist even despite prior instruction and after explicit teaching.

This aligns with Potvin et al. (2015), who argue that conceptual change requires cognitive conflict, something Ms Zyphron achieved by having learners defend incorrect answers publicly. Mr Orvex's use of DBE diagnostic reports to pre-empt common errors (e.g., surface

area misapplications) introduces a systemic approach to misconception remediation. While Black and Wiliam's (1998) formative assessment framework is widely cited, this study highlights how policy-level data can inform classroom practice—a less explored intersection.

The following section focuses on the instructional responses and intervention strategies teachers used to address the misconceptions they had identified.

6.6 Theme 4: Teacher's remedial strategies and instructional adjustments

This theme focuses on the instructional and intervention strategies teachers used to respond to the misconceptions they had identified—which was discussed in Theme 3. Structuring these two themes sequentially allows the analysis to demonstrate a coherent relationship between diagnosis and remediation, illustrating how teachers move from recognising errors to addressing them through targeted pedagogical approaches. This organisation aligns with constructivist principles, which emphasise that effective learning arises through the identification and reconstruction of misconceptions rather than the mere correction of wrong answers (Vygotsky, 1978; Bruner, 1996)

According to Niyibizi and Kazinyirako (2024), remedial strategies play a significant role in addressing academic challenges and may involve a variety of interventions. In this study, observations across multiple classrooms revealed a spectrum of techniques, with some teachers effectively scaffolding instruction and integrating technology, while others relied on more traditional methods that limited immediate feedback and learner engagement.

While observing the learners' errors and misconceptions identified by teachers, for each error and misconception a few examples were provided of remedial strategies used by the teachers to identify such errors and misconceptions in theme 3. Therefore, I referred to this theme for such examples from data as they are similar, hence no examples are provided in this section and only observations were described.

6.6.1 Error correction techniques

Mrs. Zyphron employed a scaffolding approach to address learners' misconceptions about unit conversion. Her method involved step-by-step explanations and guided practice, ensuring that learners engaged actively with the material rather than passively memorising formulas. She assigned group work, encouraging learners to collaboratively solve conversion problems and present their answers to the class. This fostered peer learning and allowed Ms Zyphron to guide the class through the reasoning process, addressing incorrect answers in a way that built

conceptual understanding. By having learners explain their reasoning, she uncovered common misconceptions and provided real-time corrections, preventing the internalisation of incorrect methods.

Mr Vexora focused on clarifying the concept of area by relating it to a real-world example, such as tiling a classroom floor. Mr Vexora explained that area represents the total space to be covered, not just the boundary, helping learners visualise the concept beyond abstract numbers. However, Mr Vexora's approach lacked the structured scaffolding and collaborative elements seen in Ms Zyphron's lessons, potentially limiting the depth of learners' understanding.

Using step-by-step explanations, Ms Tarkis addressed misconceptions about the difference between area and perimeter. She explained explicitly how perimeter measures the total distance around a shape, while area calculates the surface within it. For example, when a learner incorrectly applied the area formula to find the perimeter of a rectangle, Ms Tarkis demonstrated the correct method using a labelled diagram and real-world examples, such as comparing a garden fence (perimeter) to the grass covering the garden (area). This approach clarified the distinction; however, she did not reinforce learners' engagement and retention with interactive activities.

Ms Luneth employed a structured, step-by-step approach to correct learners' errors in Body Mass Index (BMI) calculations. When learners made errors, such as forgetting to square the height or misplacing values in the formula, Ms Luneth identified the specific mistake and guided learners toward self-correction. Peer discussions and guided practice exercises further solidified understanding, allowing learners to review and correct each other's work.

Mr Orvex fostered deep understanding by encouraging learners to articulate their reasoning before providing corrections. He used guiding questions to prompt learners to reconsider their answers and identify their own errors. This reflective approach ensured that learners engaged in critical thinking rather than relying on rote memorisation. However, as he did not explain foundational concepts explicitly, some learners may have struggled to self-correct.

6.6.2 Use of visual aids and manipulatives

Ms Zyphron integrated digital resources like Google Classroom Content to enhance her learners' understanding of unit conversion. The online materials included interactive models, videos, and exercises that visually demonstrated conversion steps and allowed learners to revisit the content at their own pace. Additionally, Ms Zyphron used physical manipulatives,

such as measuring tapes, to reinforce practical understanding. Learners measured one another and converted the values into various metric units, applying their prior knowledge from Grade 11. This combination of digital and hands-on tools catered to diverse learning styles, particularly benefiting visual and auditory learners.

In contrast, Mr Vexora did not incorporate any visual aids or manipulatives in his lesson on area. The absence of diagrams, models, or hands-on tools may have made it difficult for some learners to grasp the concept. While his real-world analogy of tiling a classroom floor provided some clarity, the lack of visual reinforcement limited the effectiveness of his instructional approach.

Similarly, Ms Tarkis relied solely on past paper questions and did not utilise visual aids or manipulatives to differentiate between area and perimeter. While past papers are useful for assessment, they may not provide the conceptual reinforcement needed for learners struggling with misconceptions. The absence of visual representations, such as labelled diagrams or interactive models, likely hindered some learners' ability to internalise the distinction between the two concepts.

Ms Luneth effectively used visual aids and hands-on activities to improve learners' understanding of BMI. She provided a BMI classification chart, which helped learners visually interpret BMI values and understand different weight categories. Additionally, learners measured their height and weight in class, calculating their BMI to practically apply the formula. These activities made abstract numerical concepts more tangible and relatable, enhancing engagement and comprehension.

Mr Orvex, however, relied primarily on past question papers to address errors and misconceptions. While past exam questions are valuable for real-world application, the absence of visual aids, such as charts or interactive whiteboards, limited learners' ability to visualize abstract concepts. However, integrating practical demonstrations or diagrams alongside exam questions could have provided alternative ways for learners to process information, particularly for those who struggle with text-based learning.

6.6.3 Feedback mechanisms

Ms Zyphron's feedback mechanisms were immediate and constructive, ensuring that learners received timely corrections. During group work presentations, she provided instant feedback, identifying and addressing misconceptions in front of the class. Additionally, learners received

immediate feedback through Google Classroom, allowing them to recognise errors and adjust their thinking quickly. This combination of peer discussions and digital feedback created a dynamic and supportive learning environment, reducing the risk of learners reinforcing incorrect methods.

Mr Vexora's feedback approach was less immediate and lacked personalisation. He assigned homework on the topic of area, leaving learners to work through their difficulties independently. Corrections were provided the following day, with the correct answers written on the board and learners marking each other's work. This delayed feedback meant that learners might have reinforced their misconceptions overnight, making it harder to correct errors later. The absence of personalised guidance or explanations further limited the effectiveness of Mr Vexora's feedback approach.

Ms Tarkis also did not provide immediate or tailored feedback. While her step-by-step explanations clarified the distinction between area and perimeter, the lack of individualised feedback meant that learners who misunderstood the concept might not have fully grasped where they went wrong. Without specific guidance, some learners likely struggled to apply the correct formulas in different contexts.

Ms Luneth ensured that feedback was immediate, constructive, and targeted. She provided specific guidance based on the type of error made, such as asking learners whether they remembered to square the height or if their answer seemed reasonable based on typical BMI values. This reflective approach encouraged learners to recognise their mistakes and think critically about their calculations. Individualised feedback and targeted practice exercises further reinforced learning, helping learners internalise the correct method.

Mr Orvex's feedback approach encouraged self-correction through guided questioning and reflective thinking. Instead of directly providing correct answers, he prompted learners to reconsider their responses and identify their own errors. While this method promoted critical thinking and problem-solving skills, some learners who struggled with foundational concepts may have benefited from more explicit explanations alongside the inquiry-based approach.

The findings highlight the varied approaches teachers employed in error correction techniques, the use of visual aids and manipulatives, and feedback mechanisms. While some teachers, such as Ms Zyphron and Ms Luneth, effectively integrated structured scaffolding, visual tools, and immediate feedback, others, like Mr Vexora and Ms Tarkis, relied more heavily on traditional methods, which may have limited their effectiveness in addressing learners' misconceptions.

These findings resonate with the existing literature on error correction and conceptual understanding in mathematics education. Research emphasises the importance of addressing misconceptions through scaffolding, visual aids, and immediate feedback (Niyibizi & Mutarutinya, 2024; Zheng & Tse, 2023). Ms Zyphron's use of group work and digital tools aligns with studies showing that collaborative learning and technology-enhanced instruction improve conceptual understanding (Aghakhani et al., 2023). Similarly, Ms Luneth's hands-on activities and targeted feedback reflect the effectiveness of practical applications and individualised corrections in addressing mathematical errors (Bennet & Sjögren, 2018; Bansilal, 2014).

Conversely, the limitations observed in Mr Vexora's and Ms Tarkis's approaches echo concerns raised in the literature about the inadequacy of traditional, teacher-centred methods for addressing misconceptions (Brodie, 2014). The lack of visual aids and immediate feedback in their lessons likely hindered learners' ability to internalise and apply concepts, as highlighted by studies emphasising the role of multimodal instruction in mathematics education (Schwarz, 2022). While theoretically sound, Mr Orvex's inquiry-based approach may not have been sufficient for all learners, underscoring the need for balanced instruction that combines inquiry with explicit guidance.

The following section explores how teachers actively used learner engagement and peer interaction as strategies to address errors and misconceptions in Measurement lessons.

6.7 Theme 5: Learner engagement and peer interaction

This section explores how teachers actively used learner engagement and peer interaction as strategies to address errors and misconceptions in Measurement lessons. Guided by the understanding that engagement and collaboration are central to conceptual development, teachers in this study adopted varying levels of interactive practices to stimulate participation, clarify misunderstandings, and reinforce learning.

6.7.1 Active participation

The teachers played an instrumental role in fostering active participation as a means of surfacing and addressing learners' misconceptions.

Ms Zyphron's lesson was characterised by significant learner engagement. Learners were active participants, responding enthusiastically to instruction and teacher prompts. They asked questions, attempted to justify their answers, and demonstrated a willingness to engage with

the material. This active participation was facilitated by Ms Zyphron's interactive teaching approach, which encouraged learners to think critically and articulate their reasoning, enabling her to identify and correct conceptual errors in real time.

In contrast, Mr Vexora adopted a teacher-centred approach, in which learners had a more passive role. While the teacher clarified concepts related to the topic of Area, learners did not actively engage with the material or ask questions. Their participation was limited to listening and taking notes, with no observable attempts to interact with the content beyond the teacher's explanations. This limited interaction reduced opportunities for him to diagnose and address misconceptions through dialogue.

Mr Quenric also encouraged participation, drawing on learners' prior knowledge of perimeter, which they were able to recall and apply during the lesson. However, their active participation was inconsistent. While some learners engaged with the material and responded to prompts, others became distracted—particularly, those who finished tasks quickly. This led to noise and disruptions, detracting from the overall engagement of the class. Although learners were attentive in Ms Tarkis's class, their participation was passive, with limited questioning or discussion. They listened carefully as she employed a step-by-step explanation method to clarify the difference between area and perimeter. However, there were no observable instances of learners asking questions or contributing to the discussion, suggesting a teacher-centred approach with limited learner involvement that restricted opportunities for learners to test or reconstruct their understanding.

Ms Luneth's lesson, on the other hand, was highly interactive. Learners actively participated by measuring their height and weight, calculating their own BMI, and applying the correct formula. This hands-on activity engaged learners and allowed them to connect the abstract concept of BMI to their personal experiences, fostering a deeper understanding of the topic, which deepened conceptual understanding and revealed errors in a supportive environment.

Mr Orvex's approach resulted in a mixed level of participation. Learners who seemed to understand the topics of area, perimeter, volume, and surface area were active, responding to prompts and engaging with the material. However, those who struggled with the concepts remained passive, indicating a disparity in engagement levels within the class.

6.7.2 Peer collaboration

Ms Zyphron's lesson included significant instances of peer collaboration. Learners worked in groups to discuss and solve conversion problems, assisting one another to address misconceptions. This collaborative approach fostered peer-to-peer learning and allowed learners to articulate their reasoning and learn from their peers' perspectives.

Mr Vexora's lesson provided limited opportunities for peer collaboration. While learners were assigned homework to work through difficulties independently, corrections were done the following day, with learners marking each other's work. However, this process lacked personalised guidance or explanations, limiting the effectiveness of peer collaboration in addressing misconceptions.

In Mr Quenric's class, learners talked to each other and discussed answers to questions, demonstrating some level of peer collaboration. However, this interaction was not uniformly productive. Learners who finished tasks quickly became distracted and started making noise, disrupting the learning environment and reducing the overall effectiveness of peer collaboration.

Ms Tarkis's lesson did not include any instances of peer collaboration. Her step-by-step explanation method was delivered in a teacher-centred manner, with no opportunities for learners to work together or assist one another in understanding the concepts of area and perimeter.

Ms Luneth's lesson, however, was rich in peer collaboration. Learners assisted one another with measurements and explained to each other why their BMI values differed. This collaborative process not only reinforced their understanding of the BMI formula but also encouraged learners to engage in meaningful discussions about the practical applications of the concept. Mr Orvex's lesson included some peer collaboration, but this was unevenly distributed. Active learners who understood the topic assisted their peers, providing explanations and guidance. However, struggling learners were often left out of these interactions, highlighting a gap in peer support for those who needed it most.

These findings resonate with existing literature on the teacher's role in using active participation and peer collaboration in addressing misconceptions. Research emphasises that active engagement and social interaction are critical for deepening conceptual understanding and correcting errors (La Hadi & Dedyerianto, 2020). Ms Zyphron and Ms Luneth's practices align with studies showing that collaborative learning and hands-on activities enhance learner

engagement and conceptual clarity (Walker et al., 2021; Langer-Osuna et al., 2020). Their use of group work and peer discussions also reflects the effectiveness of social constructivist approaches in mathematics education (Brodie, 2014).

Conversely, the limitations observed in Mr Vexora's and Mrs Tarkis's approaches echo concerns raised in the literature about the inadequacy of teacher-centred methods in fostering meaningful engagement (Levitt & Grubaugh, 2023). The lack of active participation and peer collaboration in their lessons likely hindered learners' ability to internalise and apply concepts, as highlighted by studies emphasising the importance of interactive and multimodal instruction (Schwarz, 2022). Mr Quenric and Mr Orvex's mixed results further underscore the need for structured and inclusive collaborative activities to ensure all learners benefit from peer interaction.

The following section examines how teachers actively employed teaching strategies and pedagogical approaches to identify, address, and remediate learners' errors and misconceptions in Measurement.

6.8 Theme 6: Teaching strategies and pedagogical approaches

This section examines how teachers actively employed teaching strategies and pedagogical approaches to identify, address, and remediate learners' errors and misconceptions in Measurement. Central to these strategies was the teachers' role as deliberate instructional designers—selecting and applying specific tools and techniques to bridge conceptual gaps and strengthen learners' understanding. The findings reveal that teachers did not respond to errors passively; rather, they intentionally adapted their pedagogical methods to promote clarity, support conceptual reconstruction, and guide learners toward accurate reasoning.

Two prominent strategies emerged across classrooms: the use of instructional aids and the application of learner support and scaffolding techniques. Both were central to the teachers' efforts to make abstract Measurement concepts concrete, correct misconceptions, and enhance conceptual retention.

6.8.1 Use of instructional aids

Teachers' integration of instructional aids into their teaching varied significantly across the observed lessons, with some teachers incorporating diverse tools to enhance conceptual understanding, while others relied on more traditional resources. Ms Zyphron demonstrated extensive use of instructional aids, integrating technology and physical resources to support

learning. She employed Google Classroom as a platform for learners to access materials, assignments, and activities. She also created a handbook consolidating activities on conversions, which served as a reference for learners. The use of a projector and smartboard facilitated visual engagement, while previous past examination papers provided a structured approach to problem-solving. Furthermore, real-life examples of conversions were embedded into Ms Zyphron's teaching to contextualize mathematical concepts.

In contrast, Mr Vexora's approach was more traditional, as he did not incorporate technology into his instruction. However, he utilized real-life examples to relate mathematical concepts to practical situations, aiming to bridge the gap between abstract concepts and everyday experiences. Mr Vexora's method focused on verbal explanations and direct teaching without additional visual or technological tools.

Mr Quenric relied primarily on textbooks as his primary instructional aid, limiting the range of resources available to learners. Mr Quenric's teaching centred on textbook exercises, complemented with the use of a chalkboard for writing notes. While some learners had access to calculators provided by the DBE, there were not enough for all the learners, which may have hindered their ability to perform calculations efficiently.

Similarly, Ms Tarkis depended on handouts, particularly of previous examination question papers, as the main instructional resource. No visual aids or technological tools were incorporated into her lessons, which resulted in a highly text-dependent teaching approach.

Ms Luneth ensured that learners had access to textbooks, calculators, and supplementary printed copies of extra activities, which were pasted into their exercise books for further practice. She also utilized physical measurement tools, such as a ruler, measuring tape, and three-dimensional models—including a cylinder, square, rectangular box, and a triangle—to facilitate hands-on learning experiences in Measurement. These tools allowed learners to engage with mathematical concepts practically, reinforcing their understanding through direct manipulation of objects.

Mr Orvex's classroom was significantly constrained in terms of resources. As there were only 10 textbooks, the teacher retained them and distributed them for shared use during lessons, which may have impeded individual engagement with the material. Some learners possessed calculators, while others did not. The teacher spent a substantial amount of time writing notes on the board, sometimes delegating this task to learners, instead of providing printed copies. This was because the school had run out of ink and paper and was waiting for a new order to

arrive. Technology was not utilised at all in Mr Orvex's classroom, further limiting instructional diversity.

6.8.2 Learner support and scaffolding techniques

Scaffolding techniques, aimed at gradually reducing support as learners develop confidence and independence, were implemented differently across the classrooms, with varying degrees of effectiveness. Ms Zyphron employed a structured scaffolding approach, ensuring that learners had ongoing opportunities to engage with the material at their own pace. She regularly updated activities on Google Classroom, enabling learners to complete tasks independently while receiving feedback. Additionally, she provided copies of previous question papers and their marking guidelines, allowing learners to practice problems and correct their work. This method fostered self-directed learning and encouraged learners to take ownership of their academic progress.

Mr Vexora implemented scaffolding through step-by-step demonstrations, guided practice, and real-world problem-solving tasks. His approach focused on gradual skill development, ensuring that learners had sufficient practice and support before attempting tasks independently. However, unlike Ms Zyphron, Mr Vexora did not provide ongoing digital resources or structured self-assessment tools to facilitate independent learning outside the classroom.

In contrast, Mr Quenric did not gradually remove support but rather maintained a highly teacher-centred approach. He provided explanations of the differences in formulas for area and perimeter and demonstrated techniques for substituting correct values into formulas. However, he did not help learners transition towards independent problem-solving as he remained the primary source of knowledge transmission throughout the lesson, limiting opportunities for learner autonomy.

Ms Tarkis adopted a step-by-step explanation method to guide learners through the content. However, unlike the other teachers, who provided structured in-class activities for reinforcement, she assigned practice exercises as homework. This approach placed the responsibility of practice and consolidation on learners outside the classroom, potentially reducing opportunities for immediate feedback and support.

Ms Luneth's scaffolding approach was uniquely adapted to her learners by incorporating their mother tongue, Afrikaans, as the language of instruction. Since Afrikaans was also the

language of examination, this strategy ensured that learners could grasp mathematical concepts without linguistic barriers, thereby reinforcing understanding and confidence. Ms Luneth's use of language as a support mechanism facilitated clearer comprehension and a smoother transition to independent learning.

Mr Orvex did not implement any structured scaffolding techniques. Learners were expected to follow along as he wrote notes on the board, with minimal opportunities for guided practice or gradual progress towards independence. The absence of structured support mechanisms meant that learners who struggled with the content were left without additional assistance, potentially affecting their ability to effectively engage with and retain mathematical concepts.

Variations in teachers' use of instructional aids and scaffolding techniques across the observed lessons highlight the diverse teaching strategies employed by the different teachers. While some teachers provided enriched learning environments with ample resources and structured support, others relied on more traditional, teacher-centred methods with limited opportunities forcing learners to engage independently at home. These findings provide insight into how different pedagogical approaches influence learner participation, comprehension, and self-directed learning in the classroom.

The findings of this study are consistent with literature that emphasises the pedagogical value of using multiple representations and scaffolding in mathematics teaching. Faujiah and Yarmi (2024) argue that visual tools, manipulatives, and digital resources can support conceptual understanding; in this study, teachers such as Ms Zyphron and Ms Luneth purposefully integrated such aids into their lessons. While this research did not measure the impact of these aids on learning outcomes, the observed practices reflect teaching approaches that align with evidence-based recommendations in mathematics education. Similarly, the scaffolding techniques employed by Mrs Zyphron resonate with findings by Intan and Masriyah (2020) and Penelitian et al. (2025), who report that guided instructional support can facilitate conceptual clarity and reduce misconceptions. However, this study focused on how scaffolding was used rather than its measurable effects.

Research by Saat et al. (2024) highlights the potential of digital tools to enhance engagement and address errors in mathematics. The absence of technology in some classrooms in this study contrasts with these recommendations, suggesting a missed opportunity to integrate technology-enhanced learning. Furthermore, challenges observed in Mr Orvex's classroom mirror those identified by Awoyale et al. (2024), who note that under-resourced schools often

face difficulties implementing effective mathematics instruction due to limited access to teaching materials. While the findings align with established best practices, they also point to contextual constraints that continue to affect the quality of mathematics teaching and learning in resource-limited environments.

The following section presents the findings on teachers' assessment and feedback practices observed during lesson observations.

6.9 Theme 7: Assessment and feedback

This section presents the findings on teachers' assessment and feedback practices observed during lessons.

6.9.1 Formative assessment techniques

Classroom observations revealed variations teachers' use of formative assessment techniques. Ms Zyphron employed a combination of questioning, in-class exercises, and quick checks for understanding. Similarly, Ms Luneth utilised questioning and hands-on, interactive in-class exercises to assess learners' understanding in real-time. Mr Vexora also integrated formative assessment through open-ended questioning, classroom discussions, and hands-on problem-solving exercises, encouraging learners to engage with the material actively.

The other teachers exhibited less varied approaches. Mr Quenric relied primarily on probing questions, which were employed only during correction sessions rather than throughout the lesson. Ms Tarkis used questioning techniques and in-class exercises—but without interactive engagement, limiting their effectiveness. Mr Orvex, in contrast, applied in-class exercises as the sole means of formative assessment, without the inclusion of questioning or other techniques to gauge learners' comprehension in an interactive manner. These variations highlight differing levels of formative assessment techniques and depth in the choice of formative assessment practice used across the observed lessons.

6.9.2 Feedback practices

The findings revealed variation in how teachers employed feedback as a strategy to engage with learners' errors and misconceptions during Measurement lessons. Across classrooms, feedback served different functions—ranging from immediate verbal clarification to delayed collective review—but its application and depth varied significantly among teachers.

Ms Zyphron provided interactive and immediate feedback throughout the lesson. She frequently paused instruction to comment on learners' responses, prompting them to explain their reasoning and guiding them toward accurate conceptual understanding. Her feedback approach was dialogic and responsive, allowing misconceptions to be identified and addressed in real time. Similarly, Ms Luneth offered clear and encouraging feedback during practical activities, prompting learners to reflect on their calculations and correct misunderstandings through teacher-led questioning and peer discussion. In both classrooms, feedback functioned as a formative teaching tool integrated into ongoing instruction rather than as a separate evaluative step.

In contrast, Mr Vexora relied primarily on delayed feedback. He typically assigned homework for learners to complete independently and addressed errors the following day by writing correct answers on the board. Learners then marked each other's work, but without personalised explanation or teacher-led clarification. This approach limited opportunities for learners to engage with or verbalise their misconceptions during the lesson itself. Similarly, Mr Orvex provided feedback drawn from common errors identified in previous tests and DBE reports. Although this allowed him to highlight typical mistakes, the feedback was general and not adapted to individual learners' difficulties.

Mr Quenric employed probing questions during correction sessions, using learners' responses to elicit explanations of how they had arrived at particular answers. While this encouraged reflection and classroom discussion, some learners continued to rely on peers for clarification, suggesting that feedback in his lessons often operated at a collective rather than an individual level. In Ms Tarkis's classroom, feedback was primarily procedural. Her focus on step-by-step explanations helped clarify content but did not extend to personalised dialogue or formative questioning that could reveal deeper conceptual misunderstandings.

Overall, these findings show that teachers in the study used feedback in varied ways—some integrating it actively within instruction, others applying it retrospectively or at a generalised level. Teachers such as Ms Zyphron and Ms Luneth demonstrated feedback practices aligned with formative assessment principles that emphasise interaction and clarification, while teachers like Mr Vexora and Mr Orvex adopted more traditional, corrective feedback approaches. This variation reflects differences in how teachers interpret and operationalise formative feedback in classroom contexts.

The findings align with literature highlighting that feedback is most effective when it is interactive, specific, and contextualised (Sadler, 1989; Fu & Li, 2020). However, as noted by Schildkamp et al. (2020), formative assessment must be used purposefully and responsively to support learning. While this study did not measure the impact of feedback on learner outcomes, the observed classroom practices contribute to understanding how feedback is used as a pedagogical strategy to identify and address misconceptions in Measurement. Additionally, the instructional strategies employed by teachers in addressing learners' errors can also be interpreted through the principles of social constructivism. Teachers frequently guided learners step-by-step through measurement problems, provided demonstrations, and encouraged peer discussion when misconceptions were identified. These practices reflect the concept of scaffolding, where teachers provide structured support to help learners progress from their current level of understanding toward more advanced conceptual knowledge (Vygotsky, 1978). Within this process, teachers function as the More Knowledgeable Other (MKO), assisting learners in navigating conceptual difficulties within their Zone of Proximal Development (ZPD). Through guided questioning, demonstrations, and corrective feedback, teachers supported learners in reconstructing their understanding of measurement concepts.

6.10 Chapter summary

This chapter has explored how the Mathematical Literacy teachers who participated in this study engaged with learners' misconceptions and errors in the topic of Measurement, addressing Research sub-question 2. Through detailed classroom observations and analysis, the study revealed a wide range of teaching practices, strategies, and challenges that influence how teachers identify, diagnose, and address learner errors. The findings highlighted the importance of classroom organisation, instructional strategies, formative assessment, and feedback mechanisms in shaping the effectiveness of teachers' engagement with misconceptions. The findings demonstrated that engagement with learners' misconceptions in Measurement requires a multifaceted approach that combines constructivist teaching strategies with practical, evidence-based interventions. While some teachers successfully implemented these strategies, others faced significant challenges due to resource constraints and overcrowded classrooms. The next chapter presents the findings of the study that relate to Research sub-question 3: 'Why Mathematical Literacy teachers engage or do not engage with learners' errors and misconceptions'.

CHAPTER 7: FINDINGS ON TEACHERS' PEDAGOGICAL REASONS FOR ENGAGING OR NOT WITH LEARNERS' ERRORS AND MISCONCEPTIONS

7.1 Introduction

The previous chapter presented the findings related to the second research sub-question: 'How do Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement?' It explored the various classroom strategies teachers adopted to identify, address, and support learners struggling with Measurement concepts. Through analysis of semi-structured interviews and classroom observations, the chapter highlighted approaches such as scaffolding, use of real-life contexts, visual aids, and continuous assessment techniques. Building on that foundation, this chapter presents findings related to the third research sub-question: 'Why do Mathematical Literacy teachers engage, or not engage, with learners' errors and misconceptions?' In this chapter, the emphasis is on understanding the underlying motivations, beliefs, challenges, and reflections that shape teachers' decisions to either address or overlook learner misconceptions in Mathematical Literacy (ML) Measurement.

The chapter draws on data collected from semi-structured interviews with the six ML teachers who participated in this study and integrates these findings with the literature reviewed in Chapter 2. Through this thematic analytical process, the chapter aims to illuminate the complex interplay between teachers' pedagogical philosophies, contextual realities, and reflective practices in shaping their responses to learners' difficulties.

7.2 Identification of themes

From the analysis of the interview data three major themes, with associated sub-themes, emerged: pedagogical beliefs and motivation, contextual and institutional barriers, and reflective practice and use of feedback. The themes, sub-themes, and emerging findings are summarised in Table 10.

Table 10

Themes and new emerging findings

Theme	Subtheme(categories)	Emerging finding
1. Pedagogical Beliefs & Motivation	Personal commitment to learner success Belief in inclusive and supportive teaching Perceived importance of conceptual clarity	o Emotional detachment o Dual instructional roles
2. Contextual & Institutional Barriers	Time constraints Resource limitations Class size	o Cultural linguistic barriers
3. Reflective Practice & Use of Feedback	Learner feedback as a guide Use of assessment data Continuous self-reflection	o Informal reflective tools

The findings are organised according to these themes and sub-themes in the following sections. Participant responses are used illustratively to anchor the findings, and where appropriate, these responses are situated within the broader scholarly discourse to highlight alignment with, or divergence from, the existing literature.

7.3 Theme 1: Pedagogical beliefs and motivation

This section presents findings related to the first major theme —teachers' pedagogical beliefs and motivation—as it relates to engagement with learners' errors and misconceptions in Measurement. The data revealed that teachers' engagement was strongly influenced by their underlying beliefs about the purpose of teaching, their responsibility toward learners, and the role of errors in the learning process. The analysis of interview transcripts yielded three sub-themes under this broad category: (1) personal commitment to learner success, (2) belief in inclusive and supportive teaching, and (3) perceived importance of conceptual clarity.

7.3.1 Personal commitment to learners' success

During the interviews, several teachers expressed a deep personal commitment to their learners' academic growth and overall success. Ms Zyphron stated:

> *"I want them to succeed; thus, I try everything to help them avoid misconceptions and errors."*

This belief appeared to act as a powerful motivator for identifying and addressing learner misconceptions. Mr Vexora exemplifies this view, stating:

"Since I believe in imparting knowledge and seeing changes in learners' performance, addressing these errors and misconceptions helps with deeper understanding and confidence in mathematical concepts."

Similarly, Mr Orvex said:

"I'm always motivated to address misconceptions because I believe in aiming for a 100% pass rate. Every learner can succeed if they understand the basics, and fixing errors early is key to that success."

Mr Orvex's motivation was closely linked to a desire to facilitate learners' progress and ensure that misconceptions did not become entrenched.

Similarly, Ms Tarkis expressed a strong sense of responsibility toward her learners' development:

"I'm motivated by seeing my learners improve and succeed, despite the challenges we face... I'm determined to see them succeed, and that's why I push them hard during extra classes."

These responses illustrate that the drive to support learners' success went beyond curricular requirements and was rooted in these teacher's personal dedication to educational outcomes.

The literature also highlights the role of teachers' commitment in effective instructional practice. Studies such as Hoth et al. (2022) suggest that a teacher's commitment to learners' growth is a key predictor of proactive engagement with misconceptions, particularly when that commitment is grounded in a belief in all learners' potential to improve.

7.3.2. Belief in inclusive and supportive teaching

Closely aligned with the commitment to learner success is the belief in the value of inclusive and supportive teaching practices. Several teachers framed their approach to addressing misconceptions within a broader teaching philosophy that emphasises learner-centredness and inclusivity. Mr Orvex stated:

"My personal teaching philosophy is that mistakes are opportunities to learn, so I never ignore them."

This statement reflects a teaching philosophy in which the response to errors is not punitive, but constructive, positioning misconceptions as necessary steps toward deeper understanding,

rather than signs of failure, and as a crucial part of a holistic support strategy aimed at equipping learners not only for the subject at hand but also for broader academic success. Ms Luneth and Ms Tarkis expressed similar ideas. Ms Luneth said:

> *"I believe that if these misconceptions are not addressed early, they will lead to cumulative confusion in later topics, such as data handling or financial mathematics. My personal philosophy is that every learner can improve if given the right support."*

Ms Tarkis said:

> *"Addressing misconceptions is important because if we don't fix these issues early, they will carry the same problems into their exams."*

These examples suggest a belief system grounded in equity and support, where each learner is viewed as capable of improvement if given appropriate instructional attention. This inclusive orientation is aligned with the findings of Glovňová (2020), who found that teachers who viewed errors as natural and necessary for learning were more likely to engage constructively with learners' misunderstandings. The data from this study supports the claim that inclusive beliefs are central to consistent engagement with conceptual difficulties.

7.3.3 Perceived importance of conceptual clarity

A third sub-theme that emerged relates to teachers' views on the role of conceptual clarity in Mathematics learning. Several participants stressed that addressing misconceptions was not merely about correcting wrong answers but about ensuring learners build a sound conceptual foundation. Ms Luneth emphasised that confidence develops from direct intervention:

> *"... every learner can improve if given the right support, and addressing errors directly gives them the confidence to tackle more complex problems".*

Her response reflects the belief that correcting misconceptions is foundational to developing learner confidence, suggesting that conceptual clarity and self-assurance are mutually reinforcing.

Similarly, Mr Vexora stated that

> "*addressing these errors and misconceptions helps with deeper understanding and confidence in mathematical concepts".*

This statement reinforces the idea that the act of correcting errors is not procedural, but developmental, enabling learners to internalise key mathematical relationships rather than memorise isolated facts, indicating conceptual understanding as central to learners confidence and progress.

Ms Zyphron said:

> *"I try to prepare learning for the unexpected by guiding them to solve problems in everyday situations. It is important to foster critical thinking in learners to prepare them for the future."*

Here, the emphasis shifts to the broader value of conceptual clarity, showing that addressing misconceptions is tied to equipping learners with transferable problem-solving skills that extend beyond classroom assessment.

Mr Orvex stated:

> *"If I don't address their misconceptions, it could affect their performance not just in Mathematical Literacy but in other subjects as well."*

His response highlights a view of misconceptions as educationally consequential, suggesting that unresolved conceptual gaps have a cumulative effect that can hinder learning across the curriculum.

For these teachers, tackling misconceptions is part of a broader commitment to conceptual mastery, which they view as essential for developing critical thinking and problem-solving skills. This focus on conceptual clarity is echoed in the literature. Pan et al. (2020) emphasises the importance of early identification and correction of misconceptions as a means of building lasting understanding. In this study, the emphasis placed by participants on conceptual development underscores the alignment between their beliefs and the broader pedagogical goals articulated in the mathematics education literature.

These finding above indicate that while most of the teachers expressed a belief in learners' capability, the strength of these beliefs varied. Notably, Mr Orvex presented strong evidence, while Mr Quenric stood out as the only participant who did not state a belief in learners' potential or a learner-centred approach, despite showing some motivation to complete the curriculum. Mr Quenric stated:

> *"To be honest, I don't always have time to address every mistake. I try, but I'm learning with them. I don't enjoy teaching Mathematical Literacy, so I just try to get through the curriculum. I know it's important to fix their mistakes, but I'm also under pressure to cover all the topics before exams. It feels like there's never enough time."*

This variation reflects a spectrum of pedagogical motivation, with some teachers driven primarily by learner growth and others constrained by disengagement or disinterest in the subject. While these variations align in many respects with the existing literature, this study reveals an under-explored dimension: teachers' 'emotional detachment'. As revealed in the interview with Mr Quenric, a lack of affinity with the subject may significantly diminish a teacher's engagement with learner misconceptions. This highlights the need to consider emotional and motivational factors, particularly teachers' interest in teaching the subject, as potential contributors to learner support practices, an aspect not widely foregrounded in previous studies.

7.4 Theme 2: Contextual and institutional barriers

The second core theme that emerged from the data pertains to contextual and institutional barriers that influence the extent to which Mathematical Literacy teachers engage with learner errors and misconceptions in Measurement. Teachers reported a variety of systemic and environmental constraints that shaped their day-to-day instructional decisions. These constraints often intersected in complex ways, creating environments that either supported or inhibited active engagement with learner misunderstandings. The three key sub-themes identified for this theme are: (1) time constraints, (2) resource limitations, and (3) class size.

7.4.1 Time constraints

Across the interviews, time constraints emerged as a pervasive and recurring barrier affecting teachers' ability to address learner misconceptions in Measurement. All six participants referred, in varying degrees, to the tension between curriculum pacing and the need for diagnostic or remedial engagement. While the concern was universal, teachers articulated it from different standpoints—some emphasised the structural pressures of curriculum coverage, others pointed to competing school activities, large class sizes, or their own limited content confidence as compounding factors. Mr Vexora noted:

> *"There is limited time, and I sometimes prioritise covering the contents of the curriculum rather than attending to learner errors and misconceptions."*

His statement reflects a pragmatic prioritisation of curriculum coverage, where instructional pacing is privileged over remedial support due to systemic pressure to complete prescribed content.

Ms Zyphron reported:

> *"Classes are often too short because of other school related activities."*

This response points to the structural constraints that reduce effective teaching time, illustrating how non-instructional demands compete with academic priorities.

Ms Luneth described the same issue:

> *"Time constraints are a major challenge. I often don't have enough time to address all individual misconceptions in a large class, especially with limited teaching periods."*

Her comment highlights how time pressure is intensified by class size, suggesting that the challenge is not only temporal but also logistical, limiting opportunities for personalised corrective feedback.

These response highlights a pragmatic prioritisation of curriculum coverage over remedial intervention. This concern was amplified by Mr Quenric, who explained*:*

> *"Time is a big problem. I have to rush through the lessons to stay on track, and I can't stop for every mistake."*

His reflection underscores the tension between pacing and pedagogical depth, where the need to progress through content outweighs the opportunity to diagnose and correct emerging errors. Additionally, Mr Quenric's lack of confidence in his knowledge of the subject further exacerbated his time constraints challenges as he indicated:

> "*I don't feel confident in teaching this subject, so that slows me down, too".*

This reveals that time pressure is not only externally imposed but is also shaped by teacher self-efficacy, with limited subject confidence compounding instructional delays.

These accounts underscore the practical challenges teachers face when expected to balance curriculum pacing with the need for diagnostic and remedial teaching. The experience of Mr Orvex adds further weight to this issue. He stated:

> *"The only real barrier is time, especially when we have a packed curriculum to get through. But I make sure to integrate revision into every lesson so that we're constantly reinforcing what they've learned."*

Unlike others, his response reveals a compensatory strategy, showing how time constraints can be partially mitigated through instructional design rather than additional teaching hours.

Ms Tarkis described her response to the issue of inadequate time:

> *"Time is always an issue because we have a lot to cover, but I make time by holding extra classes, the time allocated for teaching measurement is not sufficient."*

Her approach reflects a personal commitment and willingness to extend instructional time beyond formal timetables, suggesting that some teachers respond to structural limitations through voluntary labour rather than pedagogical shortcuts.

The data therefore indicate that 'time' was not experienced as a single, uniform obstacle, but rather as a multi-layered constraint that shaped instructional decisions, pedagogical priorities, and the extent to which misconceptions could be addressed in real time. Several teachers described a pragmatic prioritisation of curriculum completion, often at the expense of slowing down to work through errors in depth. Others acknowledged the same challenge but reported developing strategies to mitigate it, such as integrating revision into lessons or offering extra classes outside formal contact hours. These differentiated responses reveal both the systemic nature of the time-pressure problem and the individualised ways teachers navigated it. The findings also resonate with existing research, such as Frank et al. (2020), who highlights how restricted instructional time in mathematics classrooms often results in superficial assessment practices and reduced opportunities for meaningful learner support.

7.4.2 Resource limitations

A second barrier that shaped teachers' willingness and capacity to address learners' misconceptions was the limited availability of instructional resources directly required for diagnosing and correcting errors in Measurement. The challenge was not simply a lack of general teaching materials, but the absence of specific, hands-on tools and visual supports that enable teachers to demonstrate concepts, identify where misconceptions occur, and provide remedial explanations.

Several participants indicated that without adequate resources, their ability to detect misconceptions early and intervene meaningfully was constrained. Ms Tarkis indicated that:

> *"Resources are limited, so I have to be creative with how I teach, using whatever we have. We don't have textbooks and rely heavily on copies if the machines are working and learners lose them."*

This example illustrates how teachers often had to improvise due to infrastructural inadequacies. Her statement shows that when learners lacked reliable access to worked examples or explanatory texts, she spent more time recreating content than engaging with conceptual errors. Ms Luneth reported the same issue, highlighting the difficulty of addressing misconceptions when learners do not have the necessary instruments:

> *"There are resource limitations. I don't always have enough physical materials, like rulers or protractors, to make measurement concepts tangible for every learner."*

Her account emphasises the importance of concrete, tactile tools in supporting conceptual understanding, suggesting that the absence of such materials not only restricts learner participation but also reduces opportunities for teachers to identify the source of errors.

Similarly, Mr Quenric stated:

> *"Resources are limited too. I don't have enough tools or materials to explain concepts better."*

His statement reinforces the recurring theme that the lack of subject-specific tools weakens pedagogical clarity, making corrective instruction less precise and more reliant on verbal explanation alone.

Ms Zyphron focused on learners' lack of equipment:

> "*Learners are not equipped with the necessary tools such as rulers, calculators measure bands, et cetera."*

Her response shifts the focus from teacher resourcing to learner resourcing, showing how the absence of basic tools disrupts not only teaching but also the independent cognitive work learners must do to correct misconceptions.

The lack of basic mathematical tools directly impacts the extent to which learners can engage meaningfully with Measurement tasks, making it more difficult to identify and address underlying misconceptions. These challenges are echoed in the existing literature. Sun et al. (2022) emphasise that the availability of quality teaching aids significantly enhances a teacher's

ability to clarify difficult concepts. Conversely, inadequate resources can undermine both teacher efficacy and learner understanding, particularly in abstract areas such as Measurement.

Interestingly, Mr Orvex provided a contrasting account:

> *"Honestly, I don't face many challenges. I'm fortunate to teach in a school that values education highly, and I have access to all the resources I need, from technology to teaching aids."*

His experience highlights the role of institutional context in shaping pedagogical possibility, showing that resource-rich environments allow teachers to devote attention fully to conceptual development rather than having to devise logistical workarounds. Thus, his experience supports the argument made by Bettini et al. (2020), which asserts that context, including administrative support and access to resources, shapes the conditions under which teachers operate and the strategies they can employ.

7.4.3 Class size

The third sub-theme relates to class size and its influence on instructional practices. Several participants indicated that large class sizes made it difficult to provide individualised support or address learner misunderstandings promptly. Ms Luneth observed:

> *"Class size is also an issue. With larger classes, it's difficult to give every learner the attention they need to address their unique misunderstandings."*

Mr Vexora and Mr Quenric expressed the same issue:

> *"Also, since I have a large class, it also becomes difficult to reach every learner's needs."* (Mr Vexora)

> *"Class size also makes it hard. I have large classes, and I can't give attention to each learner's problems."* (Mr Quenric)

Ms Zyphron described the added behavioural challenges associated with overcrowded classrooms:

> *"Bigger classes are disruptive, and disrespectful learners hinder others to achieve education."*

In such settings, the teacher's role shits focus from instruction to managing classroom disruptions, further reducing the teacher's time and attention available for engaging with errors. To cope with this, Ms Tarkis reported implementing learner-led support structures:

> *"Class sizes are big, so I try to give extra attention only to struggling learners as the one performing assist me, as they are a well-oiled machine. I also encourage group work so that they can help each other, which makes things a bit easier."*

This strategy, while effective under the circumstances, highlights a compensatory approach that may not guarantee equitable support for all learners. The challenges associated with large classes are widely reported. Lee (2022) and Litsch et al. (2021) both argue that smaller class sizes are associated with improved learner engagement and better teacher-learner interaction, which facilitate the identification and resolution of misconceptions.

The analysis shows that all six participants experienced at least one of the contextual barriers discussed, with variation in intensity. The findings also reveal a unique, context-specific insight: the emergence of dual instructional roles, where some teachers (such as Ms Tarkis) extended their workday and adopted informal mentorship structures to compensate for institutional shortcomings. This extends the existing literature by demonstrating how teachers navigate systemic limitations creatively, especially in resource-constrained contexts.

7.4.4 Language as a barrier to addressing learner errors and misconceptions

Challenges related to language as teachers addressed learner errors and misconceptions in Measurement within the Mathematical Literacy classroom emerged as a unique finding. Teachers working in English-medium classrooms consistently reported that language is a major barrier to learners' understanding of Measurement concepts (Wilson & Mavor, 2023). In South Africa, these challenges are most pronounced in classrooms where learners speak various African languages at home but are taught and assessed in English (Wilson & Mavor, 2023; Mavuru & Ramnarain, 2020). Mr Quenric explained:

> *"One of the biggest barriers I face is that most of my learners are not fluent in English, which is the language of learning and teaching. I explain concepts in English, but I can tell they are not processing it fully. Sometimes they confuse the terminology like 'millilitres' and 'millimetres' simply because the words sound similar, and they don't grasp the context. I have to keep switching to Sesotho or isiXhosa, depending on who*

is in front of me, but that takes time, and I worry that I'm excluding others when I do so."

His comment illustrates how linguistic misunderstanding can mask itself as mathematical misunderstanding, revealing that conceptual errors often stem from language processing rather than content deficiency. This comment underscores the disconnection between the language of instruction and learners' cognitive access to mathematical terms. Similarly, Ms Tarkis noted:

"Misconceptions arise because learners misunderstand the language used in questions. For example, a question that says, 'Calculate the area of the shaded part', they don't always understand what 'shaded' means. I've seen that unless I translate or paraphrase it, they go off-track. The curriculum expects them to work in English, but their comprehension is low. This affects even basic tasks. They know how to do the math, but they misinterpret what the question is asking."

Her account reinforces the point that errors are not always numerical but often linguistic, suggesting that comprehension barriers can interrupt otherwise correct procedural thinking.

Mr Vexora added:

"The language barrier affects how learners engage with word problems. Some learners just skip the reading part and wait for me to interpret it for them. They don't always ask when they're confused. I think they're scared of being embarrassed."

His reflection highlights the affective dimension of language barriers, where fear of embarrassment suppresses learner participation and prevents the clarification of misconceptions.

The data from this study reaffirm a well-established pattern in South African mathematics and science education: language is not a peripheral factor but a central determinant of whether teachers are able to diagnose and address learners' misconceptions effectively. Consistent with the findings of Wilson and Mavor (2023) and Mavuru and Ramnarain (2020), the teachers in this study showed that misconceptions in Measurement frequently originate not from lack of mathematical ability, but from linguistic misinterpretation of concepts, task instructions, and technical vocabulary. The confusion between terms such as 'millilitres' and 'millimetres', or the misunderstanding of words such as 'shaded', echoes wider evidence that learners struggle both with general English proficiency and the specialised register of scientific language (Setati

et al., 2002; Wilson & Mavor, 2023). As a result, what appears to be a mathematical error is often a language-processing error, masking learners' true conceptual capability.

7.4.4.1 The challenge of multiple home languages

Three teachers reported the challenge of navigating classes where multiple home languages were represented, including Setswana, Sesotho, and isiXhosa. Mr Quenric stated:

> *"I know Sesotho and Xhosa, but my learners speak Tswana as well. It's difficult to balance. Some benefit when I explain in their language; others get left behind."*

His statement shows how multilingualism, though culturally rich, becomes pedagogically complex when the teacher cannot linguistically accommodate all learners equally.

Similarly, Ms Tarkis remarked:

> *"Sometimes, I get a learner to help translate for peers. But that slows down the lesson, and I can't always be sure the explanation is accurate."*

This highlights the unintended consequence of peer translation, where time is lost and conceptual clarity depends on learners' own linguistic competence rather than the teachers.

Mr Vexora added:

> "*I realised that language is the real barrier, not the maths. But switching between three languages would slow the lesson. I lose valuable time, so I switch to my own mother tongue."*

His response reveals a forced prioritisation, where instructional flow is preserved at the expense of linguistic inclusivity. These testimonies illustrate the difficulty of using the mother tongue effectively in multilingual settings without formal support structures.

The teachers' reliance on code-switching to mediate meaning reflects a common strategy in multilingual South African classrooms, where teachers draw on learners' home languages to bridge the gap between everyday discourse and academic terminology (Mavuru & Ramnarain, 2020; Probyn, 2019). However, as the participants indicated, this strategy is limited by the absence of equivalent scientific vocabulary in many African languages and further complicated by the presence of multiple home languages within a single class. These constraints mirror national studies showing that translanguaging often becomes reactive and inconsistent rather than a structured pedagogical approach (Probyn, 2019; Setati et al., 2002). The data therefore

reinforce the argument that multilingual realities cannot be solved by teacher improvisation alone but require systemic pedagogical and curricular support (Mavuru & Ramnarain, 2020; Wilson & Mavor, 2023).

7.4.4.2 Systemic constraints on language use

Teachers also expressed concern that the requirements of the education system undermine their language use strategies. Ms Tarkis reported:

> *"Even if I explain in their language, learners must write in English. So I always have to go back and forth and translate everything for them. It sometimes becomes a bit much with the workload I have to cover the curriculum."*

Her comment reflects the tension between responsive pedagogy and assessment policy, showing how teachers are compelled to mediate between linguistic accessibility and institutional compliance.

Mr Vexora stated:

> *"We're told to prepare them for exams, and those are in English. There's no room to really support them in their home languages because I will not be there in the exam room to explain what the paper requires in their language, so I just stick to English."*

This highlights a systemic contradiction: while mother-tongue scaffolding supports learning, high-stakes examinations in English limit its sustained use.

Thus, this second layer of tension identified in the data related to systemic and assessment pressures, where teachers feel compelled to prioritise English because high-stakes examinations are conducted in English only. This aligns with broader scholarship demonstrating how monolingual assessment policies restrict teachers' ability to support conceptual understanding, even when they recognise the pedagogical value of home-language use (Abdalgane & Elmahdi, 2024; Hamad et al., 2025). As the teachers in this study expressed, the obligation to 'prepare learners for the exam' often results in superficial engagement with misconceptions, because classroom language choices are subordinated to assessment compliance — a pattern also noted by Woltran and Schwab (2025).

Taken together, the data and literature reveal that this challenge is not merely linguistic but structural: multilingual learners are required to learn and demonstrate conceptual understanding in a language that is not their own, while teachers are held accountable to

policies that limit flexible language use. This confirms growing calls for curriculum reform, teacher training in multilingual pedagogies, and more inclusive assessment practices that recognise learners' linguistic repertoires as cognitive resources rather than barriers (Mavuru & Ramnarain, 2020; Wilson & Mavor, 2023; Abdalgane & Elmahdi, 2024).

7.5 Theme 3: Reflective practice and use of feedback

Reflective practice is widely recognized as a key factor in enhancing teachers' effectiveness in Mathematics education. Teachers who actively engage in reflective practices are more likely to revisit, correct, and deepen learners' understanding of concepts, rather than stopping at surface-level error correction or ignoring misconceptions (Agnihotri, 2024; Acharya et al., 2024). Reflective practice fosters self-awareness, allowing teachers to critically evaluate their instructional strategies and adapt them to better support student learning outcomes (Agnihotri, 2024; Kilic, 2022).

This theme explains how teachers' level of engagement with learners' misconceptions is shaped by their orientation toward reflection and feedback loops. In alignment with the literature, the data suggest that teachers who actively seek evidence of whether their instruction is working or not are more likely to revisit, correct, and deepen learners' understanding of Measurement concepts, whereas teachers who do not engage in reflective practices tend to stop at surface-level error correction or avoid returning to misconceptions once the lesson is finished. In this sense, reflective practice acts as an internal motivator for some teachers to keep engaging with errors, while its absence becomes an unintentional barrier for others.

Thus, what may initially appear to be teachers 'checking their own teaching' is, in fact, a critical mechanism that determines whether misconceptions are treated as temporary mistakes or as diagnostic entry points for deeper learning. This theme shows that teachers' degree of engagement with learner errors and misconceptions was strongly influenced by the extent to which they used reflection and feedback systems to detect whether misconceptions persisted after teaching. The data suggest that teachers did not simply choose to engage or not engage with errors based on belief or intention alone, but were largely guided by the evidence they created—or failed to create—about what learners still misunderstood.

Where teachers actively sought feedback, analysed assessment data, or reflected critically on their strategies, they were more likely to re-engage with learner misconceptions, rather than assume they had been resolved. In contrast, where such practices were absent or superficial, teachers tended to disengage from misconceptions prematurely, believing that teaching equals

learning. Thus, reflective practice functioned as a mechanism of sustained engagement, while its absence produced unverified closure. Three sub-patterns emerged within this theme: (1) learner feedback as a guide, (2) use of assessment data, and (3) continuous self-reflection. The section therefore contributes directly to Research Question 3 by showing that teachers' beliefs about the usefulness of feedback and reflection strongly influence whether they persist in addressing misconceptions or regard them as already resolved after instruction.

7.5.1 Learner feedback as a guide for continued engagement with misconceptions

For some teachers, learner feedback—whether formal or informal—served as a diagnostic tool to decide whether further engagement with misconceptions was necessary. Teachers who elicited feedback from learners were able to determine whether misconceptions were still present and therefore needed renewed attention.

Of the six teachers, Mr Orvex demonstrated the strongest orientation toward learner-driven evaluation. He explained:

> *"I regularly ask learners to reflect on what they've understood and where they're still struggling."*

Similarly, Ms Luneth said:

> *"I also seek feedback from learners by asking them to reflect on which areas they feel more confident in after the lesson".*

In both cases, feedback was not used as general classroom interaction, but as a mechanism for diagnosing whether previous intervention had actually addressed the misconception. This allowed the teacher to re-engage, when necessary, rather than assuming the error had disappeared.

Other teachers used learner feedback in a less structured manner. Mr Quenric explained:

> *"Sometimes, I ask them for feedback, but I don't have a formal system to see if they're improving".*

Ms Tarkis, similarly, used learner feedback in a less structured manner. She said:

> *"I just informally talk to them to ask where they are struggling and perhaps it's something about my teaching strategies contributing to their misunderstanding and how I can improve myself,"*

Here, feedback occurred, but without a clear tracking mechanism, limiting its potential to inform further engagement. Other teachers perceived the collection of feedback from learners as impractical or counterproductive. The teachers who did not collect feedback tended to disengage from the misconception once they had taught the content. Ms Zyphron stated:

> *"I do not seek feedback from learners on a regular basis as it takes too much time and they tend to make a joke of it."*

The absence of learner feedback means the teacher lacks information about whether misunderstandings remain, which in turn reduces engagement with errors beyond the initial lesson. Ms Zyphron's account highlights a perceived cultural or behavioural barrier to feedback collection, which may undermine efforts to foster reflective teaching practices.

When feedback is actively sought, teachers acquire information that triggers re-engagement with misconceptions. When feedback is absent, teachers have no evidence that the misconception persists and therefore disengage—not because they believe misconceptions are unimportant, but because they have no mechanism for detecting their continuation. These findings align to a degree with those of Pan et al. (2020), who found that teachers who value learner input are better positioned to correct misconceptions. However, the hesitancy to seek feedback observed among some participants also reflects broader challenges in shifting classroom dynamics to support feedback-rich environments.

7.5.2 Use of assessment data to verify whether misconceptions have been resolved

Assessment data served as another tool that enabled teachers to confirm whether their earlier efforts to address misconceptions had been effective. Rather than assume that a misconception had been corrected, some teachers deliberately compared learners' performance before and after intervention to determine whether conceptual understanding had improved. This was clearly demonstrated by Mr Vexora, who described a structured, comparative approach:

> *"After addressing these errors and misconceptions, I give learners another class test and compare the results of the previous test with the second test to see if the performance has improved."*

Here, assessment was not used merely as a summative tool but became an instrument of verification, allowing the teacher to decide whether further engagement was necessary.

A similar orientation was evident in the approach taken by Mr Orvex, who placed emphasis on the evidence produced through repeated assessment:

"*The test results speak for themselves. I closely monitor how learners perform after each lesson, and if I see improvement in their scores, I know my strategies are working."*

Both accounts reflect a view of assessment as feedback rather than finality, where data serves as a trigger for continued instructional action. This practice of using assessment to guide instructional responsiveness was also evident in Ms Luneth's feedback-driven assessment practice:

"I use class tests and quizzes to see if learners have improved after I've addressed their misconceptions. The improvement in assessment results is a good indicator of the effectiveness of my strategies."

Ms Luneth's use of assessments appeared to be both formative and summative, serving as a tool for instructional refinement and learner evaluation. Like the previous two participants, she interpreted assessment scores not as the end of the learning process, but as a form of pedagogical evidence, guiding her determination of whether additional clarification was needed.

A comparable stance was expressed by Ms Tarkis, who broadened the monitoring process beyond formal tests:

"I use regular tests and quizzes to check if they've understood the material. I also pay close attention to how they perform during extra classes. If I see that they're improving, then I know my strategies are working."

Her account illustrates that assessment does not need to be tied only to formal contexts; even informal or supplementary learning spaces can function as diagnostic checkpoints for unresolved misconceptions. However, the data also reveal cases where assessment did not function as a diagnostic tool, but rather as a procedural requirement. In contrast to the other teachers, Mr Quenric explained:

"I just mark their tests and hope they understand a bit more each time when I give them a copy of the marking guideline or when I write the corrections on the board."

In this instance, assessment was treated as an evaluative end-point rather than a feedback loop. Because the results were not analysed for conceptual shifts, there was no mechanism prompting the teacher to re-engage with unresolved misconceptions.

The findings suggest that teachers who analyse assessment data use it as feedback to decide whether misconceptions require renewed attention, meaning that assessment functions as a catalyst for deeper engagement. When assessment is treated only as marking, misconceptions are assumed to have been corrected, even when no evidence confirms that conceptual understanding has changed.

This broad consensus supports findings from Enu and Ngcobo (2020) and Martin et al. (2022), who highlight the importance of formative assessment in identifying gaps in learners' understanding. However, while assessments are widely used, their integration with more reflective or dialogic practices remains uneven.

7.5.3 The role of continuous self-reflection in teachers' engagement

A third factor influencing whether teachers addressed misconceptions was the extent to which they reflected on the effectiveness of their instructional strategies. For some participants, reflection acted as an internal monitoring system, prompting them to return to misconceptions when their initial explanation did not produce the intended learning outcomes. This is illustrated in the practice of Ms Luneth, who described a structured method for reviewing her own teaching decisions:

> *"Personally, I keep a teaching journal where I reflect on what strategies worked and what didn't. This helps me adjust my future lessons to better address common issues."*

Her use of a reflective journal shows that continued engagement with misconceptions was not accidental, but the result of deliberate professional self-assessment that highlighted areas in need of further intervention. A similar pattern appears in the reflections of Mr Orvex, who reported a routine process of examining the success of his lessons:

> *"I also make use of self-reflection. After each class, I think about what worked and what didn't, and I adjust my approach for the next lesson."*

In this case, reflection operated as an ongoing trigger for re-engagement, ensuring that misconceptions were not regarded as resolved until the teacher was satisfied that the strategy had genuinely removed the barrier to understanding.

However, this reflective loop was not present in the practice of all participants. For some, the lack of a reflective process resulted in the assumption that misconceptions had been addressed simply because the content had been taught. Mr Quenric admitted:

"I don't really have any way to check how well my strategies work".

The absence of structured reflection meant there was no mechanism for recognising whether misconceptions persisted, which in turn limited the likelihood of returning to them once the lesson had concluded.

A similar lack of engagement was evident in the earlier comment by Ms Zyphron, who noted:

"I do not seek feedback from learners on a regular basis…"

Although this statement was made in the context of learner feedback, it also signals an absence of reflective practice because the teacher did not generate information that would allow her to evaluate the effectiveness of her strategy or decide whether additional clarification was needed.

Together, these contrasting accounts highlight the role of reflection in shaping not only how teachers respond to misconceptions, but whether they return to them at all after the initial instructional attempt. This pattern was also reported by Pan et al. (2020), who observed that while many teachers understood the value of reflection in theory, its application in practice remained inconsistent. The finding that some teachers in this study used personal journals or informal dialogue as reflective tools represents an organic approach that may not be well-documented in current literature.

These findings contribute to the growing understanding of how teachers' self-awareness and learner feedback mechanisms function in real classroom contexts. In particular, the use of informal reflective tools such as the informal consultations with learners and personal reflective journals used Ms Tarkis and Ms Luneth, offers a nuanced, context-sensitive perspective on teacher-led professional development in resource-constrained environments.

Across all three sub-themes, the central finding is consistent: teachers sustained engagement with learners' misconceptions only when they used strategies to generate evidence about whether the misconception still existed. When teachers obtained feedback, analysed assessment patterns, or reflected on the effectiveness of their strategies, they were compelled to revisit misconceptions. When these processes were absent, misconceptions were assumed to have been corrected and engagement ended—not because teachers were unwilling to engage, but because they lacked mechanisms to signal that further action was needed. This finding directly answers Research sub-question, showing that reflective practice is a reason that why some teachers continue addressing misconceptions, while others disengage after initial correction. Teachers' decision to engage, or not engage, with learners' misconceptions is

therefore not only a matter of belief, time, or pedagogical skill, but also depends on whether they create feedback mechanisms that expose lingering misconceptions in learners' knowledge.

Teachers' decisions to engage or not engage with learner misconceptions can also be understood within a constructivist framework. Constructivist pedagogy emphasises the importance of recognising learners' prior knowledge and actively engaging with misconceptions as opportunities for conceptual development. Teachers who deliberately revisited foundational concepts and encouraged learners to articulate their reasoning demonstrated an approach consistent with constructivist principles of guided conceptual reconstruction. Conversely, contextual pressures such as time constraints, large class sizes, and curriculum pacing limited some teachers' ability to engage deeply with learners' misconceptions. In such contexts, teaching may shift toward procedural correction rather than conceptual restructuring, reducing opportunities for learners to reconstruct their mathematical understanding.

7.3 Chapter summary

This chapter has presented the findings related to the third research sub-question: 'Why do Mathematical Literacy teachers engage, or not engage, with learners' errors and misconceptions in Measurement?' The analysis showed that teachers' decisions to address or overlook misconceptions were shaped by three major groups of factors: their pedagogical beliefs and motivation, contextual and institutional barriers, and their use of reflective practice and feedback. Each theme revealed different factors that either supported or limited teachers' engagement with learner errors in Measurement.

The first theme, pedagogical beliefs and motivation, showed that teachers' personal commitment to learners' success, belief in inclusive and supportive teaching, and emphasis on conceptual clarity, strongly influenced whether they addressed misconceptions. Teachers who believed that all learners are capable of learning, who viewed errors as learning opportunities, and who prioritised conceptual understanding were more likely to engage with misconceptions. However, variation emerged: while some teachers demonstrated strong motivation, others—such as Mr Quenric—reported emotional detachment from the subject, which reduced their willingness to address misconceptions even when they recognised them.

The second theme, contextual and institutional barriers, highlighted the practical challenges that made it difficult for teachers to consistently address learner errors. These included time

constraints, resource limitations, and class size. Teachers reported pressure to complete the curriculum, lack of sufficient teaching and learning resources, overcrowded classrooms, and limited opportunities for one-on-one support. In addition, language as a barrier emerged as a significant factor, with teachers explaining how learners' difficulties with English often resulted in misconceptions that were linguistic rather than mathematical in nature. Systemic constraints, such as English-only assessment policies, further limited teachers' ability to use home languages to support understanding.

The third theme, reflective practice and use of feedback, showed that teachers who used learner feedback, assessment data, and continuous self-reflection were more likely to revisit misconceptions, rather than assume they had been corrected. Teachers who sought feedback from learners, compared assessment results before and after intervention, or reflected on the effectiveness of their strategies reported stronger engagement with learners' errors. In contrast, teachers who did not use feedback or reflection tended to disengage from misconceptions after initial explanation, assuming they were resolved.

Overall, the chapter shows that teachers' engagement with learners' misconceptions was not determined by a single factor but by the interaction of their beliefs, the conditions under which they taught, and the extent to which they reflected on their teaching. Their engagement was stronger when they were motivated, supported, and engaged in reflection, but was reduced when they faced time pressure, lack of resources, large classes, language barriers, or created limited opportunities for reflection.

The next chapter builds on the findings presented in Chapters 5, 6 and 7 by synthesising the results across all three research questions. It interprets the findings in relation to the existing literature and the theoretical framework underpinning the study. Furthermore, Chapter 8 discusses the broader implications of the findings for teaching practice, curriculum policy, and teacher development in Mathematical Literacy and makes recommendations for potential areas for future research.

CHAPTER 8: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This study explored the remedial strategies that Mathematical Literacy teachers employ to address learners' errors and misconceptions in the topic of Measurement in Grade 12.

The objectives of the research were:

1. to identify the common misconceptions and errors that learners exhibit in Measurement in Mathematical Literacy;
2. to explore how Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement; and
3. to determine why Mathematical Literacy teachers engage, or do not engage, with learners' errors and misconceptions.

The corresponding main research question of the study was:

> What remedial strategies do Mathematical Literacy teachers employ to address learner errors and misconceptions in Measurement in Grade 12?

The following research sub-questions directed the focus of the research, supporting the investigation of the research question by breaking it down meaningfully:

1. What are the common misconceptions and errors that learners exhibit in Measurement in Mathematical Literacy?
2. How do Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement?
3. Why do Mathematical Literacy teachers engage or not engage with learners' errors and misconceptions?

The study was grounded in the interpretive paradigm, which assisted the researcher in establishing a coherent framework that guided the exploration of remedial strategies employed by Mathematical Literacy teachers to address learners' errors and misconceptions in Measurement. As the study intended to study people's experiences, perspectives, and histories to gain insights into this phenomenon (Greckhamer & Cilesiz, 2022; Cohen et al., 2018), a qualitative approach was adopted to gain an in-depth understanding of the phenomenon. An

exploratory case study was used to obtain rich, contextualised data that illuminated the complexities and nuances of learners' misconceptions and the contextual factors influencing the effectiveness of remedial strategies employed by teachers. Data was generated using semi-structured interviews, lesson observations, and analysis of secondary documents, including the Department of Basic Education (DBE) diagnostic reports and learner's exam scripts and exercise books.

Chapters 5, 6, and 7 presented and analysed the findings in response to the three sub-research questions. This final chapter draws together the key insights generated throughout the study and presents an integrated account of how the Mathematical Literacy teachers who participated in this study engaged with Grade 12 learners' errors and misconceptions in the topic of Measurement. While the preceding chapters have presented the findings in relation to each research question, this chapter moves beyond description to synthesis, interpretation, and reflection. It revisits the overall purpose of the study—to explore the remedial strategies teachers employ when addressing misconceptions in Measurement—and situates the findings within the broader theoretical and educational landscape of Mathematical Literacy. In doing so, the chapter demonstrates how the study contributes both to scholarly discourse on misconception research and to the practical realities of teaching Mathematical Literacy in the South African context.

The chapter is organised into several interrelated components. It begins by synthesising the main findings across the three research sub-questions, showing how misunderstandings in Measurement are shaped by a dynamic interplay of conceptual, procedural, instructional, and contextual factors. This synthesis is followed by the main conclusions derived from the study, which articulate what the findings collectively reveal about the nature of misconceptions and the conditions that either support or hinder their remediation. The chapter examines the implications of these conclusions for pedagogy, curriculum design, teacher professional development, and educational policy. These implications inform a set of evidence-based recommendations directed at key stakeholders—teachers, school leaders, curriculum developers, policymakers, and providers of teacher education. Each recommendation is grounded in the data and aims to support realistic improvement in the teaching and learning of Measurement in Mathematical Literacy.

The chapter also acknowledges the study's limitations and outlines directions for future research that could deepen and extend the work undertaken in this study. Finally, the chapter

closes with a summative reflection that reinforces the central argument of the thesis: that addressing learner misconceptions in Mathematical Literacy is not merely a matter of correcting answers but requires a shift toward constructivist, conceptually grounded, and systemically supported teaching.

8.2 Discussion of findings

This section discusses the findings in response to the three research questions through the lens of the constructivist perspective and in relation to the existing literature.

8.2.1 What are the common misconceptions and errors that learners exhibit in Measurement in Mathematical Literacy?

The findings revealed four major themes of challenges as common errors and misconceptions: procedural challenges, computational challenges, conceptual challenges, and interpretation and application challenges in learners' engagement with measurement tasks in Mathematical Literacy, discussed below.

8.2.1.1 Procedural challenges

The findings revealed a pattern of learners demonstrating persistent errors executing mathematical procedures and calculations, as evidenced by diagnostic reports (DBE, 2022; 2023), analysis of learners' work, and interviews with teachers. Learners frequently struggled to apply correct formulas, follow multi-step procedures and instructions, and interpret contextual tasks. Learners' inability to change the subject of a formula and their omission of key values or substitution of an incorrect formula reflects a superficial or fragmented understanding of measurement procedures. These errors, while procedural on the surface, often signal deeper conceptual misunderstandings or procedural misconceptions, such as those caused by learners confusing the radius and diameter, using incorrect units, and multiplying instead of dividing.

From a constructivist perspective, these procedural errors and misconceptions highlight learners' inadequate assimilation and accommodation of new knowledge within their existing cognitive structures. Piaget's theory of cognitive development suggests that learners construct new knowledge through the interaction of prior schemata and new information (Piaget, 1970; Golder & Bengal, 2018). However, this study found that learners operated with flawed or incomplete schemata. For instance, confusing radius with diameter or applying multiplication instead of division during conversions suggests learners have assimilated these concepts

incorrectly or failed to accommodate the correct relationships, resulting in persistent procedural challenges.

Constructivism posits that knowledge construction is most effective when learners engage in meaningful tasks with guided assistance (Vygotsky, 1978). Vygotsky's notion of the zone of proximal development (ZPD) posits that learners require structured support (scaffolding) to internalise procedures and mathematical relationships (Vygotsky, 1978). The absence of this scaffolding results in reliance on memorisation rather than understanding, leading to procedural failures in novel or applied contexts. In this study, teachers frequently noted that learners demonstrated difficulty manipulating formulas or understanding units, indicating that while learners could perform certain procedures independently, they were unable to progress to more complex tasks without structured guidance. This reflects Vygotsky's notion of the ZPD, where the difference lies not in learners' ability, but in the lack of scaffolding needed to help them reach their potential level of performance. Learners' lack of conceptual clarity and procedural fluency, as seen in their difficulty with real-world tasks like reading maps or interpreting time intervals, demonstrates that they were not adequately supported within their ZPD. These findings indicate that learners were provided with insufficient, or inconsistent, scaffolding. These findings underscore that learners were not merely making random mistakes but were operating with incomplete conceptual frameworks that had not been fully developed through scaffolded learning experiences.

This study's findings echo and extend the literature. Scholars such as Andriani and Nurhasanah (2021) and Baharuddin et al. (2021) have identified misapplication of formulas and syntactical errors as common procedural challenges, while Guce (2017) highlights issues in mathematical writing and the misuse of symbols. These findings align closely with the evidence presented in this study of learners' failure to follow correct mathematical syntax or measure and compute accurately. Furthermore, Booth et al. (2017) and Ndemo and Ndemo (2018) stress the role of procedural misconceptions in the misuse of formulas and confusion of unit units—problems that emerged strongly in both analysis of learners' scripts and interviews with teachers. Importantly, this study builds on existing work by demonstrating that practical measurement tasks do not simply assess learners' skills, but reveal underlying misconceptions and can even magnify them, because such tasks require learners to combine procedural, conceptual, and interpretive skills simultaneously. While tasks involving elapsed time calculation or map interpretation require the integration of multiple skills, learners were often unable to perform

this integration, leading to cascading errors indicative of deeper conceptual and procedural fragility. This reinforces that Mathematical Literacy is not only about computational ability but also about conceptual application to everyday life, which is key aim of the Mathematical Literacy curriculum.

8.2.1.2 Computational challenges

The data reveal that learners struggled frequently with computational errors and deeper misconceptions rooted in misunderstanding of Measurement concepts. These challenges were not isolated mistakes but persisted as error patterns across the areas of unit conversion, rounding, formula application, and symbolic reasoning. The data consistently identified issues such as premature or incorrect rounding, inappropriate use of multiplication or division in conversions, mixing units within a single calculation, and overreliance on calculators without showing or understanding the underlying steps. These findings suggest that learners did not merely make technical errors; they often lacked the necessary conceptual frameworks to understand when and why to apply specific procedures. This resulted in a new emergent finding: 'dual-layered errors', which are procedural mistakes coupled with conceptual gaps.

These findings align with constructivism, which emphasises the importance of guided instruction and the zone of proximal development (ZPD) (Vygotsky, 1978). Learners' dependence on calculators and memorised procedures without meaningful internalisation suggests they were operating outside of their ZPD due to inadequate scaffolding. The constructivist view stresses that knowledge should be actively constructed rather than passively received (Mulyadi, 2022; Piaget, 1977). The observed emerging findings of unit dissociation, failure to cross-check answers, and emotional detachment indicate that learners were not connecting abstract numerical processes to real-world contexts, an essential constructivist tenet for Mathematical Literacy.

These findings align with previous research that has reported that rounding and unit errors often stem from inadequate reasoning and argues that misconceptions often persist due to overreliance on rote memorisation rather than understanding (Toma et al., 2021; Morales Brignac, 2022; Makonye & Fakude, 2016). This study adds depth to this understanding by identifying nuanced and cumulative patterns, such as cascading computational errors in scale application, where one early mistake compounds into multiple incorrect calculations, and breakdown in comparative reasoning, where learners omit units or misinterpret ratios, thus failing to verify or contextualise their results.

8.2.1.3 Conceptual challenges

Learners' errors and misconceptions demonstrated gaps in their foundational understanding of concepts in Measurement. These include confusion between radius and diameter, misunderstanding the distinction between area and volume, struggling to define concepts in abstract and in application misinterpreting ratios, and being unable to justify their answers. Such errors suggest procedural lapses and deeper conceptual misunderstandings that hindered their ability to engage meaningfully with measurement tasks. Data collected from learners' exam scripts and interviews with teachers corroborate that these misconceptions persisted across different assessment and instructional contexts.

The findings affirm Hasibuan et al. (2022) and Yasseen et al.'s (2020) argument that problem-solving and logical reasoning errors often stem from conceptual gaps, compromising learners' performance and progression in mathematics. The findings extend the literature by underscoring the significance of *contextual understanding* in Measurement. Data such as the example presented in Chapter 5 in which a learner misinterpreted a floor plan to be a literal space instead of a scaled representation, illustrates learners' inability to define or justify concepts in context, highlighting their difficulty transitioning between real-world phenomena and abstract mathematical representations.

Theoretically, these findings resonate with constructivist theory, which emphasises that learners construct knowledge through active engagement with concepts rather than passive reception (Mulyadi, 2022; Piaget, 1977). The errors observed suggest that many learners had not internalised the relational structures between measurement concepts (e.g., the *diameter is twice the radius*) because instruction may have emphasised memorisation over conceptual understanding. Social constructivism argues that this reflects inadequate scaffolding to match learners' zone of proximal development to enable them to construct a deep understanding of dimensionality and proportionality (Vygotsky, 1978). Teachers' comments in the study, such as that learners were "struggling to explain concepts" simply, further indicate that their instructional practices may not have been sufficiently aligned with the constructivist principle that learners' prior knowledge should be engaged and built upon. The findings suggest that teachers need to adopt instructional strategies that emphasise conceptual clarity and relational understanding in Measurement.

8.2.1.4 Interpretation and application challenges

The findings show that learners struggled with interpreting and applying measurement concepts, core competencies of Mathematical Literacy. Learners' difficulty with interpretation, such as confusing instruments with formats, misunderstanding expressions of time like 'to' and 'past', or failing to distinguish between preparation and cooking time, suggests they lacked a clear, foundational understanding of these concepts. These issues, reflected across diagnostic reports, teacher interviews, and learner scripts, indicate a pervasive inability to decode and comprehend the demands of measurement tasks.

These misinterpretations extend beyond linguistic confusion to include symbolic and procedural misalignment, as seen when learners failed to read questions thoroughly or provided partial or multiple answers as a strategy to gain marks. Such errors reflect what Verdejo et al. (2021) describe as failures in the simplification and validation phases of problem-solving. Moreover, learners' frequent confusion when differentiating units (e.g., mm or cm), applying scale interpretations, and converting between measurement units echoes the findings of Huang et al. (2020), who attribute such difficulties to syntactic and lexical barriers. This suggests that learners are not just grappling with abstract mathematical concepts but also with language and representation systems central to interpreting measurement tasks correctly.

Learners' application errors further underscore the disconnect between classroom knowledge and real-world application. Learners' inability to convert units, their misuse of formulas, incorrect estimations, and misinterpretation of contextual terms—like 'coat', in the context of painting—reflects a lack of procedural fluency and problem-contextualisation skills. As Khalid and Pulungan (2019) assert, a lack of understanding of formula usage within contextualised problems significantly contributes to such errors. Findings derived from analysis of learners' scripts, such as the incorrect use of map scales without appropriate conversions, substantiates this claim and highlights how learners struggle with transferring mathematical knowledge to practical scenarios, a key goal of Mathematical Literacy.

These findings resonate strongly with constructivism, which posits that learners build understanding through active engagement and contextualised learning (Mulyadi, 2022; Piaget, 1977). Learners' frequent misinterpretations and misapplications suggest that rote teaching methods may have dominated in their learning environments, offering insufficient opportunities for learners to explore Measurement through authentic, real-life experiences. As

the teachers in the study noted, limited exposure to real objects and contextual scenarios undermines learners' ability to estimate and apply measurements meaningfully, supporting the constructivist emphasis on hands-on, experiential learning.

8.2.2 How do Mathematical Literacy teachers engage with learners' misconceptions and errors in Measurement?

Several sub-themes emerged that respond to this second research sub-question: classroom organisation and learning environment, lesson introduction and activation of prior knowledge, identification of misconceptions and errors, teachers' remedial strategies and instructional adjustments, learner engagement and peer interaction, teaching strategies and pedagogical approaches and assessment and feedback, as presented in Chapter 6.

8.2.2.1 Classroom Organisation and Learning Environment

Classroom organisation plays a pivotal role in teachers being able to provide learners with opportunities to confront, discuss, and resolve misconceptions. In this study, classroom settings ranged from structured, resource-rich environments to overcrowded and under-resourced classrooms, underscoring the varying degrees of pedagogical responsiveness to learner errors. Teachers like Ms Zyphron and Ms Luneth demonstrated intentional classroom design that aligned with constructivist principles. Vygotsky (1978) argues that social interaction is central to learning, especially through the zone of proximal development (ZPD), where learners achieve higher levels of understanding through collaboration and guided support (Bada & Olusegun, 2015). In this regard, Ms Zyphron's pairing of high-performing and struggling learners facilitated peer-assisted learning that allowed misconceptions to surface and be addressed through guided dialogue, a direct application of scaffolding within the ZPD. Her strategy of circulating around the classroom to monitor understanding and discreetly provide corrective feedback supports Vygotsky's (1978) emphasis on the teacher's role as a more knowledgeable other. Similarly, Ms Luneth's group-based, resource-rich laboratory environment provided learners with the tools and space to collaboratively explore Measurement concepts, correcting misunderstandings through discussion and manipulation of materials, which are practices that echo Johnston's (2020) support for constructivist learning environments.

Conversely, Mr Quenric and Mr Orvex's classroom environments exemplified how overcrowding and lack of resources significantly hinder teachers' ability to effectively identify and address learners' errors. Their inability to move around the classroom to interact with

learners and insufficient access to learning materials limited their options for formative assessment and real-time correction of misconceptions. These structural challenges reflect systemic educational inequalities that perpetuate learning gaps. Wright et al. (2019) observed that large class sizes often led to diminished learner-teacher interactions. However, Blatchford and Russell (2019) caution that class size alone is not deterministic; rather, it is how teachers manage and adapt to these conditions. This study contributes to this debate by demonstrating that while resourceful and proactive teachers can mitigate some challenges, overwhelming class sizes without sufficient support compromises teachers' ability to diagnose and remediate conceptual errors effectively.

Mr Vexora's classroom setup reveals an attempt to leverage peer dialogue to correct errors, but the fact that he did not have his own classroom, but rather move between different classrooms throughout the day, made it difficult for him to maintain consistent routines or use the same resources across lessons. While his approach encouraged learners to seek help from peers, it lacked the use of multiple modes of representation—such as visual diagrams, physical models, or demonstrations—which could have supported learners in making sense of abstract measurement concepts. This finding aligns with Hidayat et al. (2023), who argue that peer dialogue is most effective when combined with visual and tactile resources that strengthen conceptual clarity.

Ms Tarkis's preference for independent, exam-style seating to instil accountability contrasts with collaborative approaches but reflects a pragmatic response to behavioural management and preparation for summative assessments. Her strategy also demonstrates that traditional, teacher-centred approaches can still support the correction of misconceptions, especially when paired with opportunities for collaborative reflection, which she reported using during correction sessions, resulting in a hybrid model.

Furthermore, while teachers in better-resourced environments generally favoured collaborative learning, the study's findings mediate Pepkolaj et al.'s (2020) critique of group work by suggesting that the way group work plays out is conditioned by classroom structure, group composition, and teacher facilitation. Ms Zyphron's strategic pairing of learners and Ms Luneth's supportive setting minimised the disadvantages of group work, such as the potential for distraction and waste of time, which were more likely in overcrowded and poorly structured environments.

8.2.2.2 Lesson Introduction and Activation of Prior Knowledge

The findings reveal varied strategies that these Mathematical Literacy teachers employed to engage with learners' misconceptions and errors in Measurement through activating their prior knowledge. Teachers like Ms Zyphron and Mr Vexora exemplified best practices by explicitly connecting new content to learners' prior knowledge through review strategies, diagnostic assessments, and hands-on activities. Ms Zyphron's reference to the 'King Henry' song as a cross-grade mnemonic illustrates a spiral curriculum approach that supports conceptual continuity. By drawing on this strategy and implementing a hands-on measurement activity with conversions, she created an inclusive environment where learners could access new learning through familiar cognitive anchors, which is an approach supported by Hattan et al. (2024), who emphasise that activating prior knowledge enhances comprehension and facilitates the integration of new concepts.

Furthermore, incorporating baseline assessment, as demonstrated by Ms Zyphron and Ms Luneth, allowed for targeted teaching that acknowledged and corrected learner misconceptions. This aligned with the social constructivist notion of the zone of proximal development (ZPD), which posits that learners benefit most when instruction is attuned to their current understanding and scaffolded accordingly (Vygotsky, 1978; Bada & Olusegun, 2015; Golder & Bengal, 2018). These teachers aligned their pedagogical choices with constructivist principles by diagnosing and addressing knowledge gaps within their learners' ZPD.

In contrast, teachers like Mr Quenric, Mr Orvex, and Ms Tarkis adopted more procedural or correction-focused approaches that did not actively interrogate learners' misconceptions. While their strategies reinforced content retention through corrections and question-and-answer methods, the absence of structured diagnostic tools meant that misconceptions may have persisted unchallenged. This aligns with findings by Moru and Mathunya (2022), who caution against the assumption that learners retain prior content, and Yasseen et al. (2020), who argue that emphasis on procedure can compromise conceptual clarity. These teachers' approaches, though well-intentioned, may reflect the tension that teachers experience between covering curriculum content and addressing learners' misunderstanding of foundational concepts.

The use of practical, real-life tasks—such as the BMI calculations and surface area estimations used by Ms Luneth and Mr Vexora—reflects the literature's call for experiential learning (Morales Brignac, 2022; Hattan et al., 2024). These activities allowed learners to confront their

misconceptions in context, deepening their understanding through application rather than abstraction. Moreover, the use of previous examination questions by Ms Tarkis illustrates assessment as learning, bridging preparation for tests and concept reinforcement. However, the potential to identify and address deeper misconceptions was limited without the concurrent use of diagnostic checks.

These findings point to the need for a more structured and intentional use of formative diagnostic tools to pre-emptively engage with misconceptions during lesson introductions. While the teachers' use of hands-on and contextualised tasks is commendable, the impact of these strategies is maximised when preceded by or integrated with baseline assessments (Țîru, 2024; Grauerholz-Fisher et al., 2024). Teachers should be encouraged to systematically assess learners' prior knowledge—not merely assume it—to engage with learners' errors meaningfully. This calls for professional development that emphasises formative assessment literacy, the integration of constructivist principles into pedagogy, and spiral curriculum strategies.

8.2.2.3 Identification of Misconceptions and Errors

Teachers such as Ms Zyphron and Mr Quenric identified learners' difficulties with unit conversions through real-time monitoring, targeted questioning, and analysis of procedural breakdowns. For instance, Ms Zyphron's use of scaffolding and guided modelling helped surface errors such as dividing by the wrong factor or misunderstanding metric prefixes, reflecting the procedural fluency gaps that Mbonambi and Bansilal (2014) also observed in South African classrooms.

Theoretically, Vygotsky (1978) emphasises the role of social interaction in cognitive development, particularly within the learner's ZPD. Teachers' engagement strategies, such as scaffolded problem-solving (Ms Zyphron), peer discussion (Ms Luneth), and probing questions (Mr Vexora), functioned as mediated tools to support learners in navigating from erroneous reasoning to accurate understanding. For example, when learners demonstrated flawed logic (e.g., incorrectly assuming 8000g = 0.8t), the combined use of teacher questioning, scaffolded guidance, and peer explanation created cognitive dissonance, which Potvin et al. (2015) argue is essential for conceptual change. Thus, the teachers were not merely correcting answers but facilitating opportunities for learners to reconstruct their thinking through social mediation.

Literature on the diagnosis of misconceptions, including studies by Rashid et al. (2021), Davier

(2017) and Sun et al. (2022), confirms that explicit reasoning and collaborative problem-solving reveal hidden learner misconceptions more effectively than traditional assessment. This was evidenced in Ms Zyphron's and Ms Luneth's lessons, where group tasks and peer corrections led to spontaneous moments of conceptual clarification. Similarly, the persistent confusion between area and perimeter observed by Ms Tarkis and formula misapplication in surface area tasks in Mr Orvex's class align with Tastepe and Yanik's (2023) findings that learners often memorise formulas without internalising their meaning.

An important contribution of this study is that it extends the literature on formative assessment by showing how teachers' real-time classroom practices, such as circulating during group work and prompting learners to justify their methods, can serve as continuous diagnostic tools. Notably, Mr Orvex's integration of the DBE diagnostic reports to pre-empt recurring errors demonstrates how macro-level policy data can inform micro-level teaching strategies, a connection that is underrepresented in literature but critical for systems-level improvement in Mathematical Literacy. Combined with classroom-level identification strategies, this systemic awareness provides a robust framework for addressing entrenched misconceptions.

These findings are significant for curriculum implementation and teacher professional development. First, they highlight the inadequacy of rote learning and the need for instructional practices that prioritise reasoning and meaning-making. Second, the findings challenge the sufficiency of direct instruction, showing that even when teachers teach the correct procedures, learners may still default to misconceptions unless these are explicitly surfaced and addressed. Third, this underscores the importance of assessment-for-learning strategies, where errors are not simply corrected but used diagnostically to inform instruction.

8.2.2.4 Teachers' Remedial Strategies and Instructional Adjustments

The findings revealed that teachers adopted diverse instructional strategies to correct learners' misconceptions, yet their engagement varied based on the level of scaffolding, use of visual aids, and feedback mechanisms they implemented. The study's findings suggest that effective engagement with misconceptions is underpinned by an active, learner-centred approach that aligns with the principles of constructivist learning theory, particularly Vygotsky's concept of the zone of proximal development (ZPD). Teachers like Ms Zyphron and Ms Luneth strongly aligned with constructivist pedagogy by using scaffolding, real-time feedback, digital tools, and manipulatives to support learners' conceptual development within their ZPD. These findings mirror the assertions of Niyibizi and Kazinyirako (2024), who advocate for

multimodal interventions in remediation, and are further corroborated by Aghakhani et al. (2023), who highlight the benefits of collaborative and technology-supported learning in addressing complex mathematical errors.

In contrast, the more traditional, teacher-centred approaches observed in Mr Vexora's and Ms Tarkis's lessons, which relied on past paper questions, delayed feedback, and minimal use of visual aids, limited learners' opportunities to meaningfully engage with and correct their misconceptions. This echoes Brodie's (2014) critique of didactic instruction, which often fails to foster deep conceptual understanding or rectify entrenched errors. While Mr Orvex's inquiry-based method supported reflective thinking and learner autonomy, it lacked the foundational scaffolding needed for learners struggling with core concepts. This suggests that constructivist strategies are beneficial but should be carefully calibrated to learners' developmental needs.

The findings suggest a critical implication for educational practice. Remedial strategies in Mathematical Literacy should go beyond procedural correction and foster conceptual clarity through visualisation, interaction, and timely feedback. This aligns with theoretical perspectives advocating for social interaction and guided discovery as pivotal to knowledge construction (Vygotsky, 1978). The integration of multimodal tools seen in Ms Zyphron's and Ms Luneth's lessons made abstract Measurement concepts more tangible and catered to diverse learner profiles, thus improving access and equity in mathematics learning.

8.2.2.5 Learner Engagement and Peer Interaction

The findings document the use of active engagement and peer interaction, which created opportunities for learners to articulate thinking and work on misconceptions and deepening their understanding of mathematical concepts. For example, Ms Zyphron and Ms Luneth exemplified constructivist teaching practices by integrating interactive strategies, such as group work and hands-on activities, that not only prompted learners to verbalise their thinking but also enabled them to correct misunderstandings through peer-assisted learning. Their classrooms were dynamic, with learners actively constructing knowledge through inquiry, dialogue, and real-world application, thus reinforcing the constructivist notion of learning as a social process mediated by interaction within the zone of proximal development (ZPD) (Vygotsky, 1978; Habsy et al., 2023).

In contrast, the teacher-centred approaches employed by Mr Vexora and Ms Tarkis illustrate

the limitations of passive learning environments in confronting and remedying learner misconceptions. Despite clear explanations, the lack of questioning, discussion, and peer interaction in these lessons likely constrained learners' opportunities to surface and resolve their misunderstandings. These findings support literature cautioning against overly didactic methods (Levitt & Grubaugh, 2023; Grubaugh et al., 2023; Schwarz, 2022), which fail to engage learners in the cognitive processes necessary for conceptual change. Similarly, the inconsistent engagement observed in Mr Quenric's and Mr Orvex's classes highlights the importance of structured collaborative activities. While some learners were actively involved, others disengaged or were excluded from peer learning opportunities, suggesting peer interaction can become uneven and ineffective without deliberate scaffolding.

These patterns underscore the broader educational issue of learner passivity in Mathematics classrooms, particularly when teaching is not aligned with constructivist principles. Active participation and peer collaboration are not mere add-ons but are essential conditions for learners to confront and reconstruct their misconceptions. La Hadi and Dedyerianto (2020) and Langer-Osuna et al. (2020) found that social interaction enabled learners to externalise their thought processes, negotiate meaning, and develop accurate mathematical understanding. The findings of this study reinforce the need for teachers to deliberately design lessons that incorporate opportunities for exploration, discussion, and peer-supported learning, especially for Measurement topics where misconceptions are prevalent and often persistent.

8.2.2.6 Teaching Strategies and Pedagogical Approaches

The findings indicate that classes taught by teachers who employed multiple instructional aids, such as Ms Zyphron and Ms Luneth, demonstrated greater learner engagement, conceptual clarity, and opportunities for correcting errors, as opposed to those where teachers relied on minimal or outdated resources.

Theoretically, learning is most effective when learners are supported through meaningful tools and interactions within their zone of proximal development (ZPD) (Vygotsky, 1978; Golder & Bengal, 2018). Ms Zyphron's extensive use of digital platforms, visual aids, and real-life examples enacts the kind of scaffolding Vygotsky (1978) advocates, where learners receive guided support that is gradually withdrawn as competence is developed (Bada & Olusegun, 2015). Her approach provided the cognitive tools learners needed and created opportunities for self-directed learning and peer-assisted correction of misconceptions. In contrast, the teacher-centred approaches used by Mr Quenric and Mr Orvex made minimal use of scaffolding and

did not support learner autonomy, which may have inhibited learners from identifying and addressing their conceptual errors. This divergence underscores a critical implication that the persistence of learner misconceptions may be less about learners' cognitive abilities and more about the instructional environments to which they are exposed.

The literature strongly supports these interpretations. Faujiah and Yarmi (2024) assert that integrating multiple representations, including digital, visual, and tactile tools, enhances mathematical understanding by enabling learners to perceive concepts from different perspectives. Ms Luneth's use of physical 3D models and language scaffolding directly applied this principle, which helped learners internalise complex measurement concepts and correct their errors. Similarly, Intan and Masriyah (2020) and Penelitian et al. (2025) emphasise that effective scaffolding fosters independent problem-solving and conceptual refinement—both of which were evident in Ms Zyphron's classroom. On the other hand, classrooms devoid of structured scaffolding and technological integration, such as those of Mr Orvex and Ms Tarkis, fall short of these standards, potentially leaving learners' misconceptions unaddressed.

This disparity highlights broader educational issues—particularly, resource inequality and its pedagogical consequences. Awoyale et al. (2024) contend that under-resourced schools face systemic barriers to effective mathematics instruction. In this study, this was evident in Mr Orvex's case: his inability to provide individual learner resources or printed notes due to institutional constraints curtailed opportunities for differentiated instruction and responsive teaching, which are critical elements in addressing misconceptions. These findings stress the urgent need for policy-level interventions that ensure equitable resource distribution and teacher training in innovative pedagogy.

8.2.2.7 Assessment and Feedback

The findings illustrate that while some teachers adopted a responsive and interactive approach to assessment, others relied on passive or generalised strategies that limited meaningful learner engagement and correction of misconceptions. Teachers such as Ms Zyphron and Ms Luneth exemplified the constructive use of formative assessment by integrating real-time questioning, collaborative problem-solving, and immediate personalised feedback. These practices reflect the principles of social constructivism, social interaction and scaffolding as vital mechanisms for learning. Through peer discussion and guided practice, learners were supported within their ZPD to address errors and build conceptual understanding, especially critical in the complex topic of Measurement.

Conversely, the practices of teachers such as Mr Orvex and Mr Vexora, who provided delayed or depersonalised feedback (e.g., marking homework a day later or referencing only common errors from past scripts), fell short of engaging learners in correcting their misunderstandings. These teachers' feedback practices lacked the dialogic and diagnostic features central to effective formative assessment, which the literature (e.g., Fu & Li, 2020; Sadler, 1989) identifies as essential for addressing misconceptions. Sadler (1989) asserts that feedback should be specific, timely, and actionable; thus, generic or delayed feedback undermines its potential to correct faulty reasoning. Schildkamp et al. (2020) further caution that formative assessment should be deliberately structured to be impactful, underscoring a gap in the pedagogical responsiveness of some teachers observed in this study.

Theoretically, the findings reinforce the value of formative assessment as a socially mediated process through which learners refine and reconstruct understanding. The divergence in teachers' assessment practices suggests an uneven application of constructivist principles in Mathematical Literacy classrooms. While teachers like Ms Zyphron aligned closely with Vygotsky's (1978) ideas by mediating learning through questioning and scaffolding, others provided limited opportunities for learners to internalise and apply corrective feedback, thus impeding conceptual growth in Measurement. There is a clear need for sustained professional development focused on formative assessment strategies that are responsive to learners' errors and encourage dialogue.

8.2.3 Why do Mathematical Literacy teachers engage, or not engage, with learners' errors and misconceptions?

This section addresses the third research sub-question: 'Why do Mathematical Literacy teachers engage, or not engage, with learners' errors and misconceptions?' Several sub-themes emerged that illuminate the factors influencing teachers' engagement with learners' errors. These include teachers' pedagogical beliefs and motivation, which shape their instructional responsiveness; contextual and institutional barriers, which constrain their ability to act on identified misconceptions; and reflective practice and feedback use, which determine how teachers evaluate and adapt their approaches over time as presented in Chapter 7.

8.2.3.1 Pedagogical Beliefs and Motivation

In this study, those teachers who viewed their role as inherently tied to learners' growth demonstrated strong engagement with errors. Teachers like Mr Vexora and Ms Tarkis expressed a strong internal drive to foster learners' improvement. They suggested that

motivation rooted in care and aspiration for learners' success is central to how they perceived their pedagogical responsibility. This aligns with Hoth et al. (2022), who asserts that teachers' commitment to learners' achievement is a crucial driver of formative teaching practices, particularly in addressing errors proactively. This further resonates with constructivist principles, especially Vygotsky's (1978) emphasis on the teacher's role in scaffolding learners within their zone of proximal development (ZPD), where identifying and addressing misconceptions is necessary to progress to more complex concepts.

Teachers' belief in inclusive and supportive teaching practices further expands on this pedagogical orientation. Teachers like Mr Orvex and Ms Luneth approached misconceptions not as deficits to be eradicated but as opportunities for growth and deeper understanding. This mindset is consistent with social constructivist theory, which posits that learning is most effective when learners are supported in making sense of their errors within a nurturing environment. It also echoes Glovňová's (2020) findings that teachers who adopt a positive stance toward learners' errors are more likely to engage in strategies that correct misunderstandings without diminishing learners' confidence. These insights reveal that engagement with errors is an ethical and instructional act expressing inclusivity, patience, and belief in every learner's potential.

The perceived importance of conceptual clarity adds an epistemological dimension to teachers' motivation. Participants consistently noted that addressing misconceptions is essential not only for performance in Mathematical Literacy but also for cultivating critical thinking, transfer of knowledge, and real-world problem-solving, which are key goals of the subject. Pan et al. (2020) argue that early identification of conceptual misunderstandings is vital for long-term retention and application of knowledge. Teachers like Ms Zyphron and Mr Orvex illustrated this commitment by linking the correction of errors to broader educational outcomes, such as future readiness and cross-subject competence. These reflections reinforce the constructivist view that learning is not about rote performance but about internalising conceptual structures through guided exploration, error correction, and reflection.

Importantly, the variation in teachers' responses during interviews also uncovers a significant insight. Mr Quenric's response identified emotional detachment as a novel and underexplored barrier to engagement. His lack of enjoyment of teaching Mathematical Literacy and experienced of pressure to cover content over understanding illuminates how affective factors can undermine pedagogical responsiveness. While time constraints are a common challenge,

as highlighted in many curriculum studies, what stands out in Mr Quenric's case is how emotional disinvestment led to a lack of effort to engage with learner difficulties. This insight contributes a fresh dimension to the literature by suggesting that teachers' motivation cannot be fully understood without considering their emotional connection to the subject matter. This finding calls for a broader examination of teacher identity, subject affinity, and emotional well-being as integral to effective teaching, particularly in subjects like Mathematical Literacy, which often lacks legitimacy within the school curriculum.

8.2.3.2 Contextual and Institutional Barriers

The findings suggest that teachers often wanted to engage with errors but were hindered by factors beyond their control. Time pressure emerged as the most consistent challenge, confirming literature by Frank et al. (2020), emphasising that rushed curriculum coverage often precedes deep learning. Teachers such as Mr Vexora and Ms Luneth described how packed timetables and short teaching periods, exacerbated by school events and non-instructional duties, limited the time available for in-depth clarification of misconceptions. The theoretical implication of this aligns with Vygotsky's (1978) social development theory, which emphasises the importance of scaffolding within a learner's zone of proximal development (ZPD). If teachers lack sufficient time to provide such scaffolding, learners are denied opportunities for meaningful conceptual development.

Resource limitations further compound this issue. Teachers reported a lack of basic instructional materials such as rulers, calculators, and textbooks, which made it difficult for them to model abstract measurement concepts or provide differentiated support. This aligns with findings by Sun et al. (2022), who note that inadequate resources restrict teachers' ability to respond effectively to learners' errors. The absence of materials restricted the pedagogical strategies available to the teachers, especially when addressing abstract or spatially oriented misconceptions in Measurement. The experience of Mr Orvex, who faced no such constraints, illustrates the significance of institutional context in shaping instructional practices. His case confirms Bettini et al.'s (2020) assertion that well-resourced environments empower teachers to adopt best practices, including responding to learners' errors with immediacy and depth.

Class size was another critical variable limiting engagement with misconceptions. Bigger class size reduced opportunities for individualised feedback as they were overcrowded, resulting in teachers adopting coping strategies such as peer-assisted learning (Ms Tarkis) or focusing only on struggling learners (Ms Luneth). While these strategies highlight teachers' agency and

adaptative capacity, they also risk creating inequitable learning experiences, reinforcing Laitsch et al. (2021) and Lee's (2022) findings that smaller class sizes enhance learner-teacher interaction and promote deeper learning. Laitsch et al. (2021) found that in large classes, the need for classroom management often superseded opportunities for formative assessment, a concern echoed by Ms Zyphron. These findings illustrate how systemic inequities disproportionately affect disadvantaged schools, leading to unequal learning conditions across the system.

A particularly valuable insight arising from the study relates to language as both a barrier and a contextual variable that directly impacts learners' conceptual understanding of Measurement. Teachers described how learners' misunderstanding of language—for example, confusing the terms 'millilitres' and 'millimetres' or misinterpreting word problems—led to mathematical errors due not to lack of cognitive ability but to poor language comprehension. This reinforces Vygotsky's position that language is central to cognitive development and meaning-making. Yet, in the multilingual classrooms in this study where instruction was delivered in English, but learners spoke multiple indigenous languages, teachers were forced to alternate languages or rely on informal translation, which consumes time and creates the risk of misinterpretation. As Mr Vexora noted, the "real barrier" is often language, not mathematics. This finding expands the existing literature by pointing to the hidden curriculum imposed by language policy, where assessment in English disadvantages learners who could otherwise demonstrate understanding in their home language. Findings suggest that improving teachers' engagement with learners' misconceptions in Mathematical Literacy requires systemic reform, not only individual teacher effort.

8.2.3.3 Reflective Practice and Feedback Use

The data revealed that engagement was neither uniform nor guaranteed. Teachers like Mr Orvex and Ms Luneth, who solicited feedback, triangulated assessment results, and engaged in systematic self-reflection, demonstrated a higher level of responsiveness to learners' conceptual difficulties. Their approaches align with an emphasis on formative assessment, scaffolding, and the teacher's role in diagnosing and responding to the learner's zone of proximal development (ZPD). Feedback from learners enabled these teachers to identify where misunderstandings persisted, while assessment data provided a concrete basis for evaluating whether remedial strategies were effective. Reflection, whether through journaling or mental review, allowed for iterative refinement of instructional methods, confirming the concept of

the reflective practitioner (Edwards, 2023).

In contrast, participants like Mr Quenric and Ms Zyphron showed limited engagement with reflective or feedback-informed practices. Their responses suggest a more traditionalist or transmissive model of teaching, where errors are noted but not deeply interrogated. Their reluctance to solicit feedback, citing learners' immaturity or time constraints, reveals cultural and systemic barriers to adopting dialogic and reflective teaching practices. This finding corroborates Pan et al. (2020), who found that while many teachers understood the theoretical value of reflection and feedback, practical application was inconsistent and often underutilised. It also supports Enu and Ngcobo's (2020) argument that despite the widespread implementation of assessment practices, these are often summative rather than formative, limiting their impact on addressing misconceptions. The findings highlight a need to foster a culture of reflective teaching, especially in Mathematical Literacy, where learners' prior misconceptions about Measurement are prevalent and often deeply rooted.

8.2.4 Theoretical tensions between constructivist pedagogy and curriculum realities

The findings of this study also highlight an important tension within constructivist pedagogy that was discussed in Chapter 3 (cf. Ch3). Constructivist theory emphasises that meaningful learning occurs when learners actively construct knowledge through exploration, dialogue, and reflection on their prior understandings (Piaget, 1977; Vygotsky, 1978). Within this perspective, learner misconceptions are not simply errors to be corrected but valuable indicators of learners' existing conceptual structures that can be used as starting points for conceptual reconstruction.

However, the empirical findings of this study suggest that teachers often operate within institutional contexts that limit the extent to which constructivist approaches can be fully realised in practice. Teachers reported experiencing significant pressure to complete the prescribed curriculum and prepare learners for high-stakes examinations. As a result, instructional time available for exploring misconceptions in depth was often constrained. In such circumstances, teachers sometimes resorted to procedural correction strategies rather than facilitating extended conceptual discussions.

This finding reflects a broader tension between the constructivist ideal of learner-centred exploration and the structural realities of curriculum pacing and standardised assessment.

While constructivism advocates for learning processes that allow learners to confront and reconstruct their misconceptions, the demands of syllabus coverage and examination preparation may encourage more directive teaching approaches.

The experiences reported by teachers in this study therefore illustrate how constructivist pedagogy is mediated by contextual factors within the schooling system. Rather than suggesting that constructivist principles are unattainable, the findings highlight the need for educational environments that provide teachers with sufficient time, resources, and institutional support to engage meaningfully with learners' conceptual difficulties. Addressing these systemic constraints may enable teachers to more fully implement constructivist strategies for identifying and resolving misconceptions in Mathematical Literacy classrooms.

8.3 Conclusions, implications and recommendations

This section brings together the key findings of the study and presents the conclusions drawn from this investigation into how Mathematical Literacy teachers engage with learners' misconceptions in Measurement. It interprets the broader implications of the results for teaching, learning, and educational policy.

The section is organised into three interconnected parts. The first part synthesises the conclusions emerging from the study, demonstrating how misconceptions in Measurement are shaped by a combination of pedagogical practices, classroom conditions, and systemic enablers or constraints. The second part outlines the implications of these conclusions for instructional practice, professional development, curriculum design, and policy reform. The third part advances a set of explicit, practical recommendations directed at specific actors in the education system, including teachers, school leaders, curriculum specialists, policymakers, and providers of teacher education. These recommendations are not generic but are grounded in the evidence produced by the study and illustrated with functional examples to support realistic implementation in diverse school contexts. The section therefore serves as both a scholarly synthesis of the research and a bridge between empirical insight and actionable change.

The findings of this study confirm that learners' errors and misconceptions in the Measurement component of Mathematical Literacy are not merely arithmetic oversights but are rooted in deeper conceptual, procedural, and interpretive gaps. These misconceptions frequently emerge because learners are exposed to fragmented teaching that emphasises procedural completion rather than conceptual clarity, with limited opportunities to negotiate meaning, test ideas, or

engage measurement concepts in authentic contexts. Where teachers relied on teacher-centred explanations, worksheet drills, or post-task correction, misconceptions persisted and often resurfaced in more complex problem applications. However, teachers who intentionally activated prior knowledge, scaffolded learning progressively, used visual and tactile representations, encouraged peer dialogue, and incorporated formative diagnostic assessment created classroom conditions in which misconceptions could be surfaced, interrogated, and resolved. The decisive factor, therefore, was not whether learners made errors, but whether instructional practice recognised these errors as opportunities for conceptual reconstruction.

The implications of these findings extend beyond individual classrooms. At a pedagogical level, the evidence implies that Mathematical Literacy requires a shift from content delivery to concept-mediated learning, where learners are guided to internalise the underlying relationships between measurement concepts, rather than memorise formulas. At a professional level, the findings imply that teachers require sustained and subject-specific professional development in pedagogical content knowledge relating to Measurement, particularly in the areas of conceptual modelling, formative assessment, and scaffolding strategies. At a systemic level, the findings signal that teacher effort alone cannot compensate for the structural conditions that inhibit effective remediation—large class sizes, lack of resources, limited instructional time, and language barriers continue to restrict teachers' capacity to diagnose and respond to misconceptions meaningfully. The remediation of errors in Mathematical Literacy thus requires an alignment of classroom practice, school support structures, and policy intervention.

8.3.1 Recommendations arising from the study

Based on these conclusions, several recommendations are proposed in the next section below.

8.3.1.1 Recommendations for teachers

The findings underscore the need for teachers to adopt instructional approaches that prioritise conceptual understanding rather than the procedural execution of measurement tasks. Teachers should use multiple representations, real-world contexts, manipulatives, and visual models to enable learners to internalise the relationships between concepts such as area, volume, scale, and unit conversions. For instance, instead of introducing the formula for surface area abstractly, learners could first be asked to wrap cuboid boxes with paper, measure each face, and infer why the sum of the face areas equals the total surface area. Such activities allow

learners to construct meaning from experience rather than memorise procedural steps detached from context.

Teachers should also embed diagnostic assessment into lesson openings rather than only after errors appear in written work or examinations. Short verbal prompts, board-based ‘show-me’ responses, estimation challenges, or quick comparison tasks can reveal whether learners still confuse millilitres with millimetres or treat perimeter and area as interchangeable. This ensures that misconceptions are addressed proactively rather than after they have compounded. A lesson on time intervals, for example, may begin by asking learners to explain the difference between ‘to’ and ‘past’ using a clock diagram, allowing the teacher to determine whether a conceptual misunderstanding exists before proceeding to calculation-based tasks.

In addition, teachers should adopt feedback practices that require learners to articulate, justify, and reconstruct their reasoning instead of merely receiving corrections. When learners present an incorrect response, the teacher might prompt them to explain the logic behind their step, compare it to an alternative explanation from a peer, or correct the procedure while verbalising why the previous reasoning failed. This dialogic feedback deepens mathematical sense-making and aligns with constructivist pedagogy. Teacher-initiated delay in calculator use is also necessary until learners can demonstrate manual procedural fluency and awareness of unit relationships; calculator dependence should supplement reasoning, not replace it.

8.3.1.2 Recommendations for schools and school leaders

Schools should create organisational and structural conditions that enable teachers to engage meaningfully with learners’ misconceptions. This includes allocating protected time for collaborative teacher planning, joint analysis of learner work, and shared review of common errors in assessments. A weekly ‘error clinic’, for example, could allow teachers to discuss errors that recur for tasks such as surface area calculations or proportional conversions and co-design targeted interventions. Such communities of practice shift remediation from an individual burden to a collective professional obligation.

School leaders should also prioritise investment in physical and digital resources that support multimodal teaching. Simple but essential tools such as measuring tapes, grid paper, unit blocks, scale rulers, and 3D models form the foundation for concept-based instruction in Measurement. In under-resourced settings, low-cost alternatives such as re-purposed packaging boxes, chalk-drawn scale diagrams, or mobile-based measurement apps can substitute standard

materials. In classrooms where learners seldom manipulate objects, misconceptions remain abstract and unchallenged.

Flexible classroom organisation is another structural requirement. Static row-based seating reinforces passive learning and limits a teacher's mobility, which is essential for observing misconceptions in real time. Schools should allow teachers to rearrange seating into group clusters, U-shapes, or station rotations, depending on lesson goals. A teacher may, for example, designate a 'calculator-free table', a 'manipulative table', and a 'peer-explanation station' to scaffold learning through movement and collaboration. Where school timetables are rigid and lessons compressed, schools should consider block-teaching arrangements or double-period allocations for concept-heavy topics such as Measurement.

8.3.1.3 Recommendations for provincial and national policymakers

The successful remediation of learners' misconceptions depends on systemic conditions that extend beyond the individual classroom. Policymakers should prioritise reducing class sizes in Mathematical Literacy, particularly in schools serving disadvantaged communities, where overcrowding undermines teachers' ability to circulate, question, diagnose, and provide tailored support. A class of thirty learners allows for formative questioning and guided practice; a class of sixty requires survival-level management, leaving conceptual gaps unresolved.

Targeted funding allocations should be ring-fenced for Mathematical Literacy resources, ensuring that schools are not expected to remediate conceptual errors while lacking even the most basic teaching aids. Policy should also support the integration of multilingual instructional practices. In many classrooms, conceptual misunderstandings are compounded by linguistic confusion rather than mathematical inability. Allowing assessment tasks to include dual-language prompts or providing glossary support for key measurement terms in learners' home languages, would help resolve errors rooted in vocabulary rather than cognition.

Policymakers should also mandate a systematic link between DBE diagnostic data and teacher support programmes. Diagnostic reports currently list common national errors, but they are rarely converted into classroom-level pedagogical strategies. A provincial training module based on recurring errors—for instance, incorrect use of scale or confusion between squared and cubic units—would operationalise diagnostic evidence into teacher practice.

8.3.1.4 Recommendations for curriculum designers and assessment bodies

Curriculum reform should foreground conceptual progression rather than formulaic recall. Measurement concepts should be revisited across grades in increasingly complex forms, allowing learners to build conceptual continuity rather than encounter unfamiliar content at Grade 12 level. A spiral curriculum design would, for example, introduce perimeter and informal area estimation in early grades, formalise area in mid-grades, and integrate surface area, scale, and unit analysis in senior grades.

Assessment bodies should also re-design examination and classroom tasks so that they reward interpretation, reasoning, representation, and justification—not only numerical accuracy. A question on the volume of a storage container, for instance, could require learners to explain why the unit must be in cubic metres and not litres, or to critique a peer's incorrect working before providing the correct method. In this way, assessment validates conceptual understanding rather than procedural mimicry.

Teacher support materials accompanying the curriculum should include worked examples of common misconceptions, sample diagnostic questions, and strategies for conceptual correction. If learners consistently confuse radius and diameter, the support document should not only note this but also recommend a classroom routine—such as using string or dynamic geometry tools—to distinguish the two through manipulation rather than explanation alone.

8.3.1.5 Recommendations for teacher education and professional development providers

Teacher education programmes should integrate structured training on identifying, interpreting, and responding to learner misconceptions. Rather than merely teaching content, training should model how to deconstruct an error, surface its conceptual root, and scaffold the learner back to understanding. A teacher-education session may, for instance, present a learner's incorrect response to a map scale problem, invite trainees to hypothesise the reasoning behind the error, and collaboratively design a targeted intervention task.

Professional development should also address the emotional and identity-based barriers that influence teacher engagement with misconceptions. The findings revealed that teachers who felt disconnected from Mathematical Literacy as a subject were less willing to invest time in remedial engagement. Training should therefore not only equip teachers with strategies but also build subject affinity, classroom confidence, and reflective awareness. Teacher journaling,

peer-observation cycles, and structured feedback dialogues are effective mechanisms for sustaining reflective practice.

Finally, professional development should prepare teachers to use multimodal tools, digital platforms, and scaffolded questioning routines that align with constructivist pedagogy. Training sessions should not merely display manipulatives or software but require teachers to simulate a lesson segment in which they apply the tool to correct a specific misconception—for example, using a virtual geoboard to demonstrate why area cannot be measured in linear units.

8.4 Contribution of the study to the field

This study contributes to the field of Mathematical Literacy education and to research on diagnostic pedagogy by providing new conceptual, empirical, and pedagogical insights into how learner misconceptions in Measurement are identified and addressed in Grade 12 classrooms. The key contributions of the study are summarised below.

- **Conceptual contribution: Identification of dual-layer errors**

The study introduces the concept of dual-layer errors, demonstrating that many learner mistakes in Measurement involve an interaction between procedural inaccuracies and deeper conceptual misunderstandings. Rather than treating procedural and conceptual errors as separate phenomena, the findings show how surface-level computational mistakes often coexist with flawed conceptual schemas, for example, when learners confuse area and perimeter formulas while simultaneously misapplying calculation procedures. This conceptualisation extends existing research on mathematical misconceptions by illustrating how different layers of misunderstanding operate simultaneously in Mathematical Literacy tasks.

- **Empirical contribution: Classroom evidence of remediation in Grade 12 Mathematical Literacy**

The study provides detailed empirical evidence of how Mathematical Literacy teachers engage with learner misconceptions in real classroom contexts. While much of the existing literature focuses on identifying learner misconceptions, particularly in primary mathematics, fewer studies examine how teachers respond to these misconceptions in senior secondary classrooms. Through classroom observations, interviews, and document analysis, this study demonstrates how teachers identify errors, intervene during instruction, and adapt teaching strategies to support conceptual understanding in Measurement.

- **Pedagogical contribution: Diagnostic practices in everyday teaching**

The study advances the literature on diagnostic pedagogy by illustrating how everyday classroom practices can function as ongoing diagnostic tools. Practices such as circulating during group work, prompting learners to justify their reasoning, analysing learner work in real time, and using multimodal instructional aids were shown to support the identification and correction of misconceptions during instruction. These findings demonstrate how diagnostic assessment can be embedded within routine teaching practices rather than being limited to formal testing.

- **Professional contribution: Teacher affect and subject identity**

The study highlights the role of teacher affect and professional identity in shaping engagement with learner misconceptions. The findings indicate that teachers' willingness to invest time and effort in addressing errors is influenced not only by pedagogical knowledge but also by their emotional connection to Mathematical Literacy as a subject. Teachers who expressed a stronger affinity for Mathematical Literacy were more likely to engage in diagnostic teaching and conceptual remediation, whereas teachers who felt less connected to the subject tended to rely on procedural correction strategies. This insight adds a new dimension to the literature by demonstrating how teacher identity and affect intersect with pedagogical decision-making.

- **Policy and systemic contribution: Linking national diagnostics to classroom practice**

The study demonstrates how macro-level policy instruments, particularly the Department of Basic Education (DBE) diagnostic reports, can inform micro-level classroom remediation when interpreted pedagogically. The findings show that teachers draw on national diagnostic data to anticipate common learner difficulties and shape instructional responses. In this way, the study illustrates how national assessment information can support classroom-level diagnostic teaching when effectively translated into practice.

- **Contextual contribution: The role of classroom organisation and language**

Finally, the study foregrounds classroom organisation and language practices as important mediating factors in the correction of learner misconceptions. Factors such as class size, lesson pacing, group work arrangements, and multilingual communication practices influenced how effectively teachers could engage with learners' errors. By highlighting these contextual dynamics, the study shifts the discourse from viewing misconception correction purely as a

matter of teacher competence to recognising the broader systemic conditions that shape opportunities for effective remediation.

Taken together, these contributions extend existing scholarship on Mathematical Literacy by linking learner misconceptions, teacher pedagogical responses, and systemic classroom conditions within a unified analytical framework. In doing so, the study provides new insight into how misconceptions in Measurement emerge, how teachers respond to them, and how diagnostic teaching can be enacted in Grade 12 Mathematical Literacy classrooms.

8.5 Limitations of the study and recommendations for future research

As a qualitative case study involving six teachers across six schools, the findings of this study offer rich, contextually grounded insights but are not intended to be statistically generalisable. The study focused exclusively on the Measurement strand of Mathematical Literacy, which means that misconceptions identified here may not fully reflect the cognitive and instructional challenges that arise in other core topics such as Finance, Probability, and Data Handling. In addition, the study foregrounded teachers' perspectives, instructional decisions, and classroom practices; learners' voices were not directly captured, and therefore the analysis does not provide first-person accounts of how learners experience, interpret, or emotionally respond to their own misconceptions. Furthermore, although the study identified systemic constraints—including linguistic barriers, class size, curriculum pacing, and resource inequities—it did not examine specific intervention models designed to address these constraints in practice, nor did it trace the long-term impact of remediation strategies beyond individual lessons or school contexts.

These limitations open multiple avenues for further inquiry. One important direction for future research is the extension of this study into other strands of Mathematical Literacy, particularly areas such as Probability and Finance where conceptual and procedural errors are also well-documented. Comparative studies across topics would help determine whether the patterns of misconception and remediation observed in Measurement are topic-specific or symptomatic of broader cognitive and pedagogical tendencies within Mathematical Literacy. Another promising area involves deeper investigation into the affective dimensions of teaching and learning. The study revealed that teacher enjoyment, subject affinity, and emotional investment influenced the degree to which teachers engaged with learners' misconceptions; however, these dynamics were not explored in depth. Future research should therefore examine how teacher

identity, emotional labour, and beliefs about Mathematical Literacy shape their pedagogical responsiveness to learners' errors.

Given the linguistic diversity of South African classrooms, future work should also explore the role of multilingual pedagogy and translanguaging strategies in remediating misconceptions in Mathematical Literacy. Since many conceptual errors were entangled with language confusion rather than cognitive inability, studies that experimentally apply multilingual resources, bilingual scaffolding, or indigenous-language task design would provide valuable insight into how language mediation supports conceptual clarity.

A further research gap concerns the absence of learner perspectives. Including learners as co-interpreters of their own misconceptions would not only illuminate how errors are internalised but also reveal the emotional and motivational dimensions of struggling with mathematics in high-stakes contexts.

Finally, longitudinal studies are needed to determine whether constructivist, diagnostic, and misconception-focused pedagogies lead to sustained improvements in learners' understanding over time. Such research could track the effects of specific interventions—such as routine diagnostic assessment, peer-scaffolded learning, or multimodal teaching tools—across multiple terms or grade levels, thereby moving beyond single-lesson or single-topic analysis. Taken together, these directions would extend the current study by broadening its scope, deepening its theoretical reach, and strengthening its contribution to the field of Mathematical Literacy education.

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APPENDICES

Appendix A: Template for profiling participants



Teacher Profile Questionnaire

1. **Personal Information:**
    - Name:
    - School Name:
    - Contact Information:
        - Email:
        - Phone Number:
    - Years of Teaching Experience:
2. **Teaching Assignment & Experience:**
    - Current Grade(s) Teaching ML:
    - Number of Years Teaching ML in Grade 12:
    - Other Subjects Currently Teaching (if any):
    - Previous Experience Teaching ML in Grade 12 (if applicable):
3. **Qualifications:**
    - Highest Educational Qualification:
    - ML-Specific Training or Qualifications:
        - ML Training Workshops Attended (if any):
        - ML Certifications (if any):
4. **Professional Development:**
    - Participation in ML-related Professional Development:
        - ML Conferences/Seminars Attended (if any):
        - ML Webinars or Online Courses Completed (if any):

Appendix B: Approval from Free State Department of Education

Enquiries: M.Z. Thango
Ref: Research Permission: I.V Mulaudzi
Tel. 051 404 8808
Email: MZ.Thango@fseducation.gov.za

education
Department of Education
FREE STATE PROVINCE

[redacted]
Bloemfontein
9301

Dear Mrs. L. V. Mulaudzi

PERMISSION TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION: MOTHEO DISTRICT

This letter serves to inform you that you have been granted permission to conduct research in the Free State Department of Education within the Motheo Education District. The details in relation to your research project with the University of KwaZulu-Natal are as follows:

Topic: Mathematical Literacy teachers' strategies to engage with learners' misconceptions and errors in the teaching of Measurement in Grade 12.

1. **List of schools involved:** [redacted]
2. **Target Population:** Six educators teaching Mathematical Literacy in grade 12 at the selected schools.
3. **Period of research:** From the second week of February 2025 until 30 September 2025. Please note that the department does not allow any research to be conducted during the fourth term (quarter) of the academic year. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension. The researcher is expected to request permission from the school principals to conduct research at schools.
4. The approval is subject to the following conditions:
   - 4.1 The collection of data should not interfere with the normal tuition time or teaching process.
   - 4.2 A bound copy of the research document should be submitted to the Free State Department of Education, Room 101, 1st Floor, Thuto House, St. Andrew Street, Bloemfontein or can be emailed to the above-mentioned email address.
   - 4.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
   - 4.4 The ethics documents must be adhered to in the discourse of your study in our department.
5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours Sincerely,

[redacted]
Mr. MZAMO W. JACOBS
DIRECTOR: QUALITY ASSURANCE, M&E AND STRATEGIC PLANNING

DATE: 08/07/2024

Appendix C: Semi-structured interview protocol



Interview Schedule for Mathematical Literacy Teachers

Introduction

Interviewer: Good [morning/afternoon]. Thank you very much for taking the time to meet with me today. I appreciate your willingness to participate in this interview and share your experiences and insights regarding teaching Mathematical Literacy, particularly in Measurement.

This interview aims to explore the strategies you use as a Mathematical Literacy teacher to address learner errors and misconceptions in Measurement. Your insights are incredibly valuable and will contribute to a deeper understanding of how teachers engage with these challenges and develop effective remedial strategies.

I want to assure you that everything we discuss today will be kept strictly confidential. Your identity and any identifying information will be anonymised in the final report to ensure your privacy.

Before we begin, I need to make sure that you fully understand the nature of this study and your role in it. I have provided an informed consent form, which outlines the study's purpose, your rights as a participant, and the measures we will take to protect your confidentiality. Could you please confirm that you have read and understood the consent form and that you agree to participate in this study?

Participant: [Participant confirms consent verbally or signs the consent form]

Interviewer: Great, thank you. Do you have any questions before we start?

NOTE:

Errors are mistakes made by learners that can often be corrected through simple clarification or practice. These errors are typically procedural rather than misunderstandings of the concepts. **For example**, a learner might convert 1 meter to 10 centimetres instead of 100 centimetres.

Misconceptions are incorrect understandings or beliefs about a concept that learners hold. Misconceptions are often resistant to change because they are based on learners' prior knowledge or flawed intuitive reasoning. For example, A common misconception is that if two shapes have the same perimeter, they must also have the same area. For example, a learner might believe that a rectangle with a perimeter of 20 units must have the same area as a square

with a perimeter of 20 units, not understanding that the areas can be different despite the perimeters being the same.

Section A: Background Information

1. Can you please tell me about your teaching experience in Mathematical Literacy?

Prompts

- How many years have you been teaching Mathematical Literacy?
- What grades have you taught in Mathematical Literacy?
- For how many concurrent years have you been teaching Grade 12, including this year?

Section B: Common Misconceptions and Errors (RQ 2.4.1)

2. What are the sections that learners struggle with in the Topic of Measurement in grade 12?

   Prompts:
   - Why do you think learners are struggling with those sections?
   - Can you provide specific examples of possible reasons why learners are struggling with those sections?

3. What are some common misconceptions that you have observed learners have in the topic of Measurement in Grade 12?

Prompts:

- Can you provide specific examples?
- What could be the possible underlying reasons for these misconceptions? factors such as instructional methods, curriculum materials, and learner backgrounds.

4. What are some common errors that you have observed learners make in the topic of Measurement in Grade 12?

Prompts:

- Can you provide specific examples?
- What could be the possible underlying reasons for these errors? factors such as instructional methods, curriculum materials, and learner backgrounds.

5. How do you identify these misconceptions and errors during your teaching?

Prompts:

- What assessment methods do you use to identify these misconceptions and errors?
- Are there specific classroom activities that help you identify these misconceptions and errors?

Section C: Engagement Strategies (RQ 2.4.2)

6. How do you typically respond when you notice a learner has a misconception or has made an error in Measurement?

Prompts:

- Can you describe specific strategies you use?
- Do you have examples of successful interventions? If yes, please mention them.

7. Can you describe any particular strategies or activities you use to prevent or correct these misconceptions?

Prompts:

- How do you plan your lessons to address these issues?
- What resources do you use?
- Do you incorporate peer learning in your strategies? If yes, please explain how.

Section D: Reasons for Engagement (RQ 2.4.3)

8. What motivates you to address or not address learner errors and misconceptions in Measurement?

Prompts:

- How do your personal beliefs influence your approach?
- How does your teaching philosophy play a role?
- How important do you perceive addressing these issues to be?

9. What are the challenges or barriers you face when trying to engage with learner misconceptions and errors?

Prompts:

- Do you encounter time constraints? please explain how.
- Are there any resource limitations? please explain how.
- Does class size affect your ability to engage? please explain how.

10. How do you assess the effectiveness of your strategies in addressing these misconceptions and errors?

Prompts:

- How do you seek feedback from learners?
- How do assessment results inform your approach?
- How do you reflect personally on the effectiveness of your methods?

Conclusion:

Thank you so much for your time and insights today. Your contributions are incredibly valuable to this study. Before we finish, do you have any questions or additional comments you would like to share?

Once again, I want to assure you that your responses will be kept confidential. The next steps will involve analysing the data collected and preparing the final report. If you are interested, I would be happy to share the findings with you once the study is completed. Thank you again for your participation.

Appendix D: Lesson observation protocol



Classroom Observation Protocol

Classroom Observation Protocol for Mathematical Literacy Lessons

Purpose:

- To observe how teachers engage with learner misconceptions and errors in Measurement.

Critical research question

- How do Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement?

Section A: Observation Information

Observer's Name	
Date of Observation	
School Name	
Teacher's Name	
Grade Level	
Lesson Topic	

Section B: Observation Criteria

1. Classroom Context:
    - How are the learners arranged in the classroom?

Prompts after lesson: Is there any particular reason why learners are arranged this way?

2. **Lesson Introduction:**
    - How does the teacher reflect on the previous day's presentation, if the topic has already been introduced?
    - How does the teacher introduce the topic of Measurement, if the topic is to be introduced?
    - Is there any initial assessment of prior/previous knowledge or misconceptions?

3. **Identification of Misconceptions and Errors:**
    - What instances of learner misconceptions and errors are evident?
    - How does the teacher identify these misconceptions (e.g., through questioning and assessments)?
4. **Teacher's Response:**
    - What specific strategies does the teacher use to address misconceptions and errors?
    - Are there examples of corrective feedback or instructional adjustments?
5. **Learner Engagement:**
    - How do learners respond and participate?
    - Are there instances of peer-to-peer interaction and correction?
6. **Instructional Strategies:**
    - What teaching aids and resources are used?
    - What methods of scaffolding and support are provided by the teacher?
7. **Assessment Techniques:**
    - What formative assessments are used during the lesson?
    - Is any immediate feedback provided to learners?

Section C: Reflection and Notes

1. What is the overall assessment of the teacher’s engagement with learner misconceptions and errors?
2. What are the specific strengths and areas for improvement observed?
3. Are there any notable interactions or incidents during the lesson?
4. What are suggestions for further observation or follow-up?

Appendix E: Document analysis protocol



Document Analysis Protocol

Document Analysis Protocol for Learner Test/Exam Scripts and Diagnostic Reports

Purpose:

- To identify common misconceptions and errors in Measurement in Grade 12 Mathematical Literacy and to understand how teachers engage with these misconceptions and errors.

Research questions:

- What are the common misconceptions and errors that learners exhibit in the topic of Measurement in Mathematical Literacy education?
- How do Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement?

Section A: Identification Information

1. **Source**

Name of Document analyser	
School Name	
Time of analysis	
Topic	
School performance	
School quartile	
Teacher's Gender	

2. **Document Type:**

Informal Test Script	
Formal Test Script	
Assignment Script	
Investigation Script	
Exam Script	
DBE Diagnostic Report	
Exercise Book	

Section B: Analysis Criteria

1. **Content Coverage for the topic of Measurement:**
    - What sub-topics of Measurement are covered in the document?

- How well do these sub-topics of Measurement align with the Mathematical Literacy curriculum?

2. **Common Misconceptions and Errors:**
   - Identify and list common errors and provide specific examples from the documents.
   - Categorize errors into various types/categories (e.g., computational, conceptual, procedural, etc.).
   - Identify and list common misconceptions and provide specific examples from the documents.
   - Categorize misconceptions into various types/categories (e.g., computational, conceptual, procedural, etc.).
3. **Patterns and Trends:**
   - Are there differences across different learners or groups?
   - Are certain misconceptions/errors more prevalent in specific topics of Measurement?
4. **Teacher Comments and Feedback:**
   - Note any teacher comments or feedback in the documents.
   - What is the nature of the feedback (corrective, supportive, neutral, etc.)?
   - How detailed and specific is the feedback regarding errors and misconceptions?
   - Are there any suggestions or remedial instructions provided by teachers?
5. **Learner Performance:**
   - What is the overall performance of learners?
   - In which specific areas do learners struggle the most?
6. **Engagement with Misconceptions and Errors:**
   - Are there any documented strategies or remedial actions taken by teachers?
   - How effective do these engagements appear based on subsequent learner performance?
   - Is there any evidence showing that the strategies the strategies or remedial provided are effective?

Section C: post data collection analysis

1. **Implications of Identified Misconceptions and Errors:**
   - What are the broader implications of the identified misconceptions and errors on learner understanding of Measurement?
2. **Possible Underlying Reasons:**
   - What could be the possible underlying reasons for these misconceptions and errors? factors such as instructional methods, curriculum materials, and learner backgrounds.
3. **Suggestions for Instructional Improvement:**
   - Based on the analysis, what are suggestions for improving instructional strategies to address misconceptions and errors in Measurement?
   - What specific actions can teachers take to enhance learner understanding and performance?

Appendix F: Template letter seeking permission from schools



Gatekeeper letter to school principal

To the School Principal,

Dear Sir/Madam

Request for Permission to Conduct Research Study

I hope this letter finds you well. My name is Mulaudzi Lebohang Victoria, and I am a student at the University of KwaZulu Natal (UKZN). I am writing to request your permission to conduct a research study at _____secondary school. as part of my research project titled "*Mathematical Literacy Teachers' Strategies to Engage with Learners' Misconceptions and Errors in the Teaching of Measurement in Grade 12*".

The aim of this study is to explore the remedial strategies Mathematical Literacy teachers employ to address learner errors and misconceptions in Measurement. Specifically, the study seeks to:

- Identify common misconceptions and errors that learners exhibit in the topic of Measurement in Mathematical Literacy education.
- Evaluate how Mathematical Literacy teachers engage with learner misconceptions and errors in Measurement.
- Understand why Mathematical Literacy teachers engage or do not engage with learners' errors and misconceptions.

The research will involve the following activities:

- Semi-Structured Interviews: Six teachers who are currently teaching Mathematical Literacy in Grade 12 will be selected for interviews to gain insights into their strategies for addressing learner misconceptions and errors.

- ❖ Classroom Observations: Observations of Grade 12 Mathematical Literacy classes will be conducted to understand how teachers engage with learners' misconceptions and errors in real time.
- ❖ Document Analysis: Analysis of learners' test/exam scripts and activity/exercise books to identify common misconceptions and errors and how teachers address them.

The participants will be selected through purposive sampling, focusing on teachers who meet the following criteria:

- ➢ Currently teaching Mathematical Literacy in Grade 12.
- ➢ Possess at least three years of experience teaching Mathematical Literacy in Grade 12.
- ➢ Have been teaching Mathematical Literacy in Grade 12 for two concurrent years.

Confidentiality and anonymity of the teachers and the college will be maintained throughout the study and in the writing of the report. The teachers' names and the college will not be disclosed at any point during and after the study. The teachers and the college will be identified by pseudonyms. Teacher educators' participation in the study is voluntary, and they can withdraw from this study at any time. The data will be kept in a secure place by the University for a period of five years after submission of the thesis, after which the documents will be shredded, and video recording will be incinerated. All the electronic copies on my computer will be deleted.

Please find enclosed herein my contact and that of my supervisor if you have any queries regarding the study.

Student Name: Mulaudzi Lebohang Victoria Supervisor: Prof. Annatoria Zanele Ndlovu

Student Number: 223153392 ----------

[redacted] [redacted]

[redacted] [redacted]

Appendix G: Letters granting permission from six schools

[redacted]

Mrs Mulaudzi Lebohang

University of KwaZulu Natal

Permission to Conduct Research Study

I am writing to inform you that you have been granted permission to conduct your research study titled ***"Mathematical Literacy Teachers' Strategies to Engage with Learners' Misconceptions and Errors in the Teaching of Measurement in Grade 12"*** at our school, based on the following conditions:

1. There will be no financial implications for the school.
2. you will make all the arrangements concerning your research.
3. Participants must not be identifiable in any way from the results of the investigation.
4. you seek the parents' consent for minors.
5. Ensure research does not interrupt educators' time and tasks.
6. The research may not be conducted during official contact time, provided that an arrangement to do research at the school, including getting inside a classroom, has been arranged and agreed upon in writing with the principal and the affected teacher/s;
7. You must present a copy of the written approval letter from the Free State Department of Education before any research is undertaken at the school.

Yours sincerely,

[redacted]

[redacted]

2024/07/17

Mrs Mulaudzi Lebohang

University of KwaZulu Natal

Permission to Conduct Research Study

I am writing to inform you that you have been granted permission to conduct your research study titled ***"Mathematical Literacy Teachers' Strategies to Engage with Learners' Misconceptions and Errors in the Teaching of Measurement in Grade 12"*** at our school, based on the following conditions:

1. There will be no financial implications for the school.
2. you will make all the arrangements concerning your research.
3. Participants must not be identifiable in any way from the results of the investigation.
4. you seek the parents' consent for minors.
5. Ensure research does not interrupt educators' time and tasks.
6. The research may not be conducted during official contact time, provided that an arrangement to do research at the school, including getting inside a classroom, has been arranged and agreed upon in writing with the principal and the affected teacher/s;
7. You must present a copy of the written approval letter from the Free State Department of Education before any research is undertaken at the school.

Yours sincerely,

[redacted]

[redacted]

[17 July 2024]

Mrs Mulaudzi Lebohang

University of KwaZulu Natal

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Yours sincerely,

[redacted]



17/07/2024

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7. You must present a copy of the written approval letter from the Free State Department of Education before any research is undertaken at the school.



[redacted]

17th JULY 2024

Mrs Mulaudzi Lebohang

University of KwaZulu Natal

[redacted]

I am writing to inform you that you have been granted permission to conduct your research study titled ***"Mathematical Literacy Teachers' Strategies to Engage with Learners' Misconceptions and Errors in the Teaching of Measurement in Grade 12"*** at our school, based on the following conditions:

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7. You must present a copy of the written approval letter from the Free State Department of Education before any research is undertaken at the school.

[redacted]

[redacted]

17 July 2024

Mrs Mulaudzi Lebohang

University of KwaZulu Natal

Permission to Conduct Research Study

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2. you will make all the arrangements concerning your research.
3. Participants must not be identifiable in any way from the results of the investigation.
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7. You must present a copy of the written approval letter from the Free State Department of Education before any research is undertaken at the school.

Yours sincerely,

[redacted]

Appendix H: Ethical Clearance Certificate from UKZN

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Mrs Lebohang Mulaudzi (223153392)
School Of Education
Edgewood

Dear Mrs Lebohang Mulaudzi,

Original application number: 00026818
Project title: Mathematical Literacy teachers strategies to engage with learners misconceptions and errors in the teaching of Measurement in Grade 12

Exemption from Ethics Review

In response to your application received on 8 July 2024, your school has indicated that the protocol has been granted **EXEMPTION FROM ETHICS REVIEW.**

Any alteration/s to the exempted research protocol, e.g., Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through an amendment/modification prior to its implementation. The original exemption number must be cited.

For any changes that could result in potential risk, an ethics application including the proposed amendments must be submitted to the relevant UKZN Research Ethics Committee. The original exemption number must be cited.

In case you have further queries, please quote the above reference number.

PLEASE NOTE:
Research data should be securely stored in the discipline/department for a period of 5 years.

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

Yours sincerely

[redacted]

Prof Thamsanqa Thulani Bhengu
Academic Leader Research
School Of Education

Appendix I: Participant consent form (teacher)



School of Education, College of Humanities,
University of KwaZulu-Natal,
Edgewood Campus

Dear Possible Participant

INFORMED CONSENT LETTER

My name is Lebohang Victoria Mulaudzi. I am a PhD candidate studying at the University of KwaZulu-Natal, Edgewood campus, South Africa. I am interested in conducting the research study titled ***"Mathematical Literacy teachers' strategies to engage with learners' misconceptions and errors in the teaching of Measurement in Grade 12".*** To gather the information, I am interested in asking you some questions.

Please note that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a population member opinion.
- The interview may last for about 45 minutes to 1 hour.
- Any information you give cannot be used against you, and the collected data will be used for the purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalised for taking such an action.
- Your involvement is purely for academic purposes only, and no financial benefits are involved.
- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

Equipment	Willing	Not willing
Audio equipment		
Photographic equipment		
Video equipment		

I can be contacted at:

Email: [redacted]a / [redacted]

Cell: [redacted]

My supervisor is **Professor Zanele Ngcobo**, located at the School of Education, Edgewood campus, University of KwaZulu-Natal (UKZN).

Contact details: Room CU 150 Main Tutorial Building, Edgewood Campus, UKZN.

Email: ngcoboA2@ukzn.ac.za

Phone number: [redacted]

You may also contact the Research Office through:

(HSSREC Research Office)
HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

KwaZulu-Natal, SOUTH AFRICA

Tel: [redacted]

Email: HSSREC@ukzn.ac.za

Email: HSSREC@ukzn.ac.za

Thank you for your contribution to this research.

Consent

I…… (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand the purpose and procedures of the study.

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

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

I have been informed about any available compensation or medical treatment if injury occurs to me as a result of study-related procedures.

If I have any further questions/concerns or queries related to the study, I understand that I may contact the researcher at [redacted] and email [redacted].

SIGNATURE OF PARTICIPANT **DATE**

…… **……**

SIGNATURE OF PARENT (If participant is a minor) **DATE**

…… **……..**

Appendix I1: Participant consent form (example of teacher)

Consent

I [redacted] (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand the purpose and procedures of the study.

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

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

I have been informed about any available compensation or medical treatment if injury occurs to me as a result of study-related procedures.

If I have any further questions/concerns or queries related to the study, I understand that I may contact the researcher at [redacted] and email [redacted]

SIGNATURE OF PARTICIPANT [redacted] DATE 1-09-2024

SIGNATURE OF PARENT (If participant is a minor) N/A DATE N/A

Appendix J: June exam question paper

education

Department of Education
FREE STATE PROVINCE

GRADE 12

MATHEMATICAL LITERACY

PAPER 2

JUNE 2024

MARKS: 100

TIME: 2 HOURS

This question paper consists of 11 pages and an addendum with 2 ANNEXURES.

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INSTRUCTIONS AND INFORMATION

1. This question paper consists of FOUR questions. Answer ALL the questions.
2. 2.1 Use ANNEXURE A in the ADDENDUM to answer QUESTION 2.3.

   2.2 Use ANNEXURE B in the ADDENDUM to answer QUESTION 4.2.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Start EACH question on a NEW page.
5. You may use an approved calculator (non-programmable and non-graphical), unless stated otherwise.
6. Show ALL calculations clearly.
7. Round off ALL final answers appropriately according to the given context, unless stated otherwise.
8. Indicate units of measurement, where applicable.
9. Diagrams are NOT necessarily drawn to scale, unless stated otherwise.
10. Write neatly and legibly.

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QUESTION 1

1.1 Eunice bought the instruments below to monitor her child's temperature.

A



B



Study the pictures above and answer the questions that follow.

1.1.1 Write down the name of instruments represented above. (2)

1.1.2 Read the temperature displayed on instrument **A**. (2)

1.1.3 Identify the instrument (A or B) that shows the lowest temperature. (2)

1.2 During the check-up visit, the doctor advised Eunice that having a regular schedule during the day can help her child's sleep stay on track. Eunice uses the two types of clocks below to monitor the time.

A



B



Use the information above to answer the questions that follows.

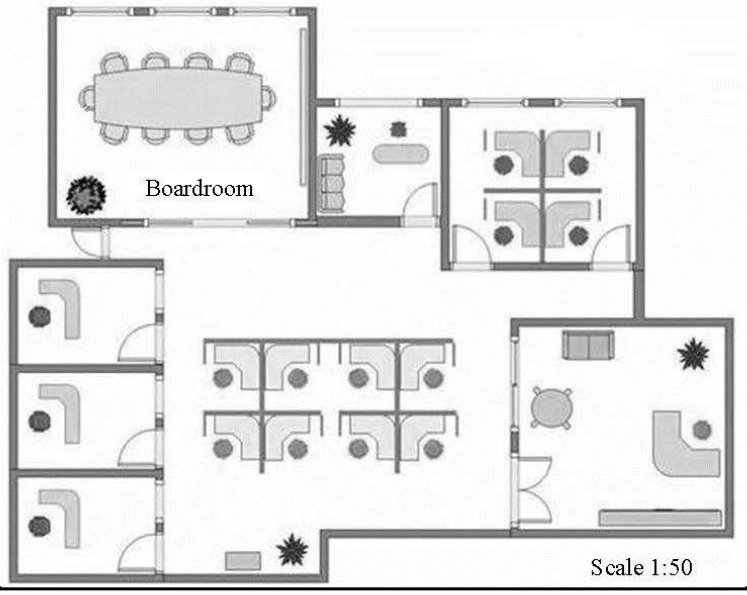
1.2.1 Write down the time displayed on clock B in words if the time format for the clock is 24-hour time.. (2)

1.2.2 The child slept at the time displayed on clock A in the afternoon. Write down the time in 24-hour format. (2)

1.2.3 Eunice went to Heilbron with the child to visit her mom. She left her home at the time displayed on clock B and arrived in Heilbron at 14:10. Determine the time, in hours, taken to reach her home (2)

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1.3 Eunice works for a small company. The picture below shows the floor plan of their office space.



Study the information above and answer the questions that follow.

1.3.1 Write down the name and the meaning of the scale on the plan. (2)

1.3.2 Explain the meaning of floor plan using the context above. (2)

1.3.3 Write down the maximum number of people who can sit around the table in the boardroom. (2)

1.3.4 State whether the following statement is TRUE or FALSE.

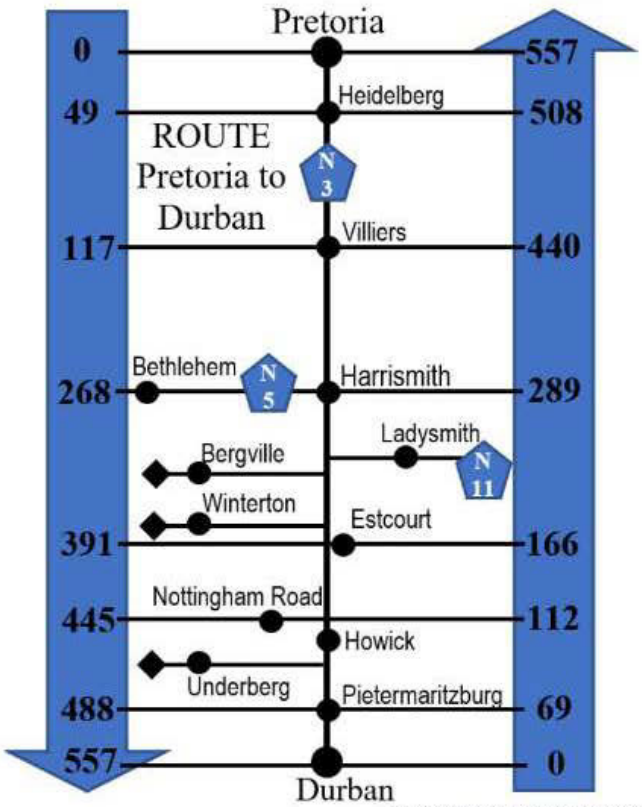
The layout plan of the office is an example of 3-Dimensional plan. (2)

[20]

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QUESTION 2

2.1 Kgotso **and his friends travelled from Pretoria to Durban to participate in the Comrade's** marathon on 9 June 2023. They used the map below to plan their trip.



[Adapted from source:learn.mindset.africa]

2.1.1 Write down the total distance that Kgotso and his friends travelled to attend the marathon. (2)

2.1.2 Choose the correct letter A, B or C that does **NOT** apply to this type of map.

A: The map is not drawn to scale

B: The actual distances are displayed

C: The roads are NOT displayed with straight lines (2)

2.1.3 Write down the national road that connects Pretoria and Durban. (2)

Copyright reserved

2.1.4 It is recommended that during a trip, drivers must take a break after they have travelled 200 km. Kgotso and his friends made their first stop at Harrismith, thereafter, they travelled for another 220 km. Write down the name of the place where they stopped. (2)

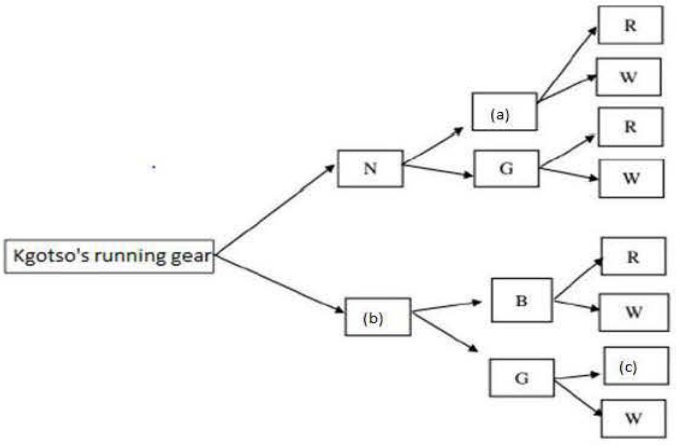
2.2 Kgotso packed 2 sets of running gear to choose from on the day of the marathon.

Running shoes: Nike (N) or Asics (A)

Running shorts: Black (B) or Green (G)

Running vests: Red (R) or White (W)

2.2.1 Complete the tree diagram below by filling in the correct letters in the place of (a), (b) and (c).



(3)

2.2.2 Determine the probability that Kgotso will use Nike shoes, Black running short, and a White vest on the day. Write down your answer as a common fraction. (2)

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2.3 Mr Naido, **who stays in Durban decides to go to Richard's Bay to go and fish there.** Use ANNEXURE A to answer the questions that follow.

2.3.1 Determine the general direction from Durban to **Richard's Bay** (2)

2.3.2 Write down ONE advantage of the scale shown on the map. (2)

2.3.3 **Convert the bar scale on the map to a ratio scale in unit form, i.e 1:…..** (4)

2.3.4 Mr Naidoo is saying that the approximate distance between Durban and **Richard's Bay on the map differs from the distance between the two places** given in the distance table below. Use the map in ANNEXURE A, accurate measurement and the distance table below to verify his statement.

Durban				
236	Ladysmith			
170	336	Richard's Bay		
356	422	195	Sodwana Bay	
134	366	303	492	Margate

(6)

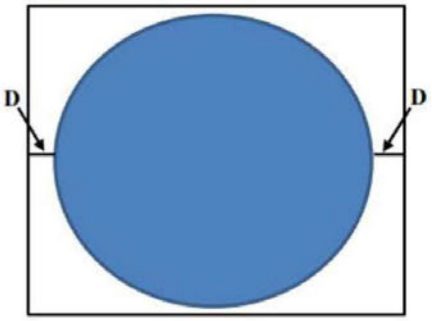
[27]

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QUESTION 3

3.1 On their way to Durban, Kgotso and his friends stopped to buy pizza. The pizza has a diameter of 40 cm and it is 20 mm thick. It was cut into 8 equal slices and served in a square box shown on the diagram below.





You may use the following formulae:

Area of a square = side × side

Area of a circle = 3,142 × radius^2

Volume of cylinder= 3,142 × radius^2× height

Use the information above to answer the questions that follow.

3.1.1 Calculate the area of the pizza box in cm^2. (2)

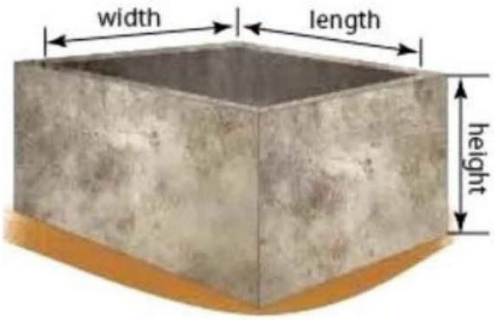
3.1.2 Determine the value of D. (3)

3.1.3 Calculate the volume of the pizza. (4)

3.1.4 Show by means of calculations that the area of **ONE** slice of pizza will be 157,1 cm^2 (2)

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3.2 Mr Dlamini makes rectangular water troughs for his animals on the farm. The concrete walls of the trough are 1 foot thick. The diagram below shows the external dimensions of the trough with an open top.



The dimensions of the tank
Length = 8 feet
Height = 5 feet
Width = 6 feet

Use the information above to answer the questions that follow.

3.2.1 Calculate the perimeter of the bottom of the trough.

You may use the formula:
Perimeter = 2 × (length + width) (2)

3.2.2 Calculate the internal dimensions of trough. (4)

3.2.3 Hence, calculate the internal volume of the trough.

You may use the formula:

Volume = Length × Width × Height (3)

3.2.4 Mr Dlamini claims that 3 litres of paint will be enough to paint the internal surface of the trough. Verify using calculation whether his claim is correct.

1,785 litres of paint cover approximately 65 feet^2.

You may use the formula:

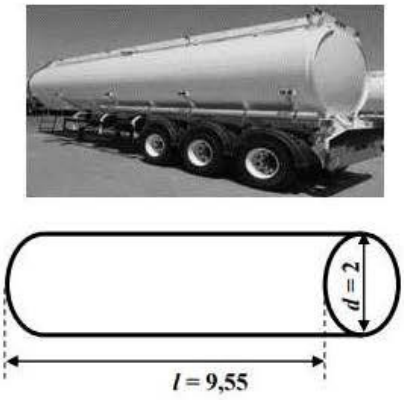
Surface area of a rectangular prism
= (length × width) + 2 (length × height) + 2 (width × height) (4)

[24]

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QUESTION 4

4.1 Mr Molebatsi bought a second hand 30 000 litres oil tanker trailer as shown in picture A below. It is used to transport oil from Cape town harbour to the oil refinery in Johannesburg.

Picture A: Oil tanker trailer	**Picture B: Oil barrel**
	
l = length in meters **d = diameter in meters**	**1 barrel = 42 US gallons** **1 litre = 0,264172 US gallons**

4.1.1 Calculate in litres, the amount of oil 1 barrel can hold. Round off to the nearest litre. (3)

4.1.2 The salesman told Mr Molebatsi that the tank can hold 190 barrels of oil. Verify showing all calculations if he is correct. (5)

4.1.3 The distance between Johannesburg and Cape town is 1398 km. The tanker trailer uses diesel at an average of 24ℓ per 100 km. The diesel price at the depot is R20,20 per litre. Mr Molebatsi claim that his cost for a return trip is R13 000. Verify with calculation whether his statement is correct. (7)

4.1.4 The driver who is driving from Johannesburg to Cape Town to deliver the oil drives at an average speed of 80km/h. He makes three stops of 20 minutes each along the road to take a break. If he leaves Johannesburg at 10:30 in the morning, write down the time he will arrive at Cape Town.

You may use the following formula:

Distance = Speed × Time (7)

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4.2 Karabo and her friends went to an opera performance at the SA State Theatre in Pretoria. Use the seating plan of the theatre on ANNEXURE B to answer the following questions.

4.2.1 How many exits are available for the performers and the orchestra? (2)

4.2.2 Write down the number of seats indicated as Zone C. (2)

4.2.3 **Explain to Karabo's friend who is seated at F4,** the shortest distance to move from F4 to R24 where Karabo is seated. (3)

[29]

TOTAL: 100

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Appendix K: Marking guideline for June exam question paper

education

Department of Education
FREE STATE PROVINCE

MID - YEAR EXAMINATION

GRADE 12

MATHEMATICAL LITERACY P2

MARKING GUIDELINE

JUNE 2024

MARKS: 100

SYMBOL/*KODE*	EXPLANATION/*VERDUIDELIKING*
M	Method/*Metode*
MA	Method with accuracy/*Metode met akkuraatheid*
CA	Consistent accuracy/*Volgehoue akkuraatheid*
A	Accuracy/*Akkuraatheid*
C	Conversion/*Herleiding*
S	Simplification/*Vereenvoudiging*
RT	Reading from a table/graph/map/diagram/*Lees vanaf tabel/kaart/grafiek/diagram*
SF	Correct substitution in a formula/*Korrekte vervanging in formule*
O	Opinion/Explanation/Reasoning /*Opinie/Verduideliking/Redenasie*
P	Penalty, e.g. for no units, incorrect rounding off, etc./*Penalisering, bv. vir geen eenhede/verkeerde afronding, ens.*
R	Rounding off/*Afronding*
NPR	No penalty for rounding/*Geen penalisering vir afronding nie*
AO	Answer only/*Slegs antwoord*
MCA	Method with constant accuracy/*Metode met volgehoue akkuraatheid*

These marking guidelines consist of 07 pages.
Hierdie nasienriglyne bestaan uit 07 bladsy

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Please turn over

NOTE:
- If a candidate answers a question TWICE, only mark the FIRST attempt.
- If a candidate has crossed out (cancelled) an attempt to a question and NOT redone the solution, mark the crossed out (cancelled) version.
- Consistent accuracy (CA) applies in ALL aspects of the marking guidelines; however it stops at the second calculation error.
- Note: consistent accuracy (CA) does not apply in cases of a breakdown.
- If the candidate presents any extra solution when reading from a graph, table, layout plan and map, then penalise for every extra item presented.

As a general marking principle, if a candidate has incurred one mistake and there is evidence of sound mathematics thereafter, then that candidate should lose one mark only

LET WEL:
- *As 'n kandidaat 'n vraag TWEE KEER beantwoord, merk slegs die EERSTE poging.*
- *As 'n kandidaat 'n antwoord van 'n vraag doodtrek (kanselleer) en nie oordoen nie, merk die doodgetrekte (gekanselleerde) poging.*
- *Volgehoue akkuraatheid (CA) word in ALLE aspekte van die nasienriglyne toegepas, dit hou op by die tweede berekeningsfout.*
- *Let wel: volgehoue akkuraatheid (CA) geld nie in die geval van 'n afbreuk nie.*
- *Wanneer 'n kandidaat aflesings vanaf 'n grafiek, tabel, uitlegplan en kaart geneem en ekstra antwoorde gee, penaliseer vir elke ekstra item.*
- *'n Algemene merkbeginsel is dat indien 'n kandidaat een fout maak en daarna voortgaan met korrekte wiskunde, dat die kandidaat slegs een punt verloor.*

QUESTION/*VRAAG* 1 [20 MARKS/*PUNTE*]			
Q/*V*	**Solution/*Oplossing***	**Explanation/*Verduideliking***	**T/L**
1.1.1	Thermometer ✓ ✓A	2A correct instrument (2)	M L1 E
1.1.2	36.8 ^{0}C ✓ ✓A 36,8 ^{0}C	2A correct reading **NPU** (2)	M L1 E
1.1.3	B ✓ ✓A	2A correct answer (2)	M L1 E
1.2.1	✓A ✓A Twenty to eleven in the morning	1A twenty to eleven 1A morning (2)	M L1 E
1.2.2	✓ ✓A 13:50	2A correct time (2)	M L1 E
1.2.3	14:10 – 10:40 ✓ MA = 3 hours and 30 minutes = 3,5 hours ✓ C	1MA subtraction 1C conversion to hours (2)	M L1 M

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	Solution/*Oplossing*	**Explanation/*Verduideliking***	**T/L**
1.3.1	Number Scale/Ratio/Numeric ✓A ✓A 1 cm on the scale drawing is 50 cm in real life /1 cm op die skaaltekening is 50 cm in die werklikheid . OR 1 unit on the map / paper is equivalent to 50 units in real life /on the ground . 1een heid op die kaart / papier is ekwivalent aan 50 eenhede in werklikheid/op die ground.	1A correct name 1A correct meaning (2)	MP L1 E
1.3.2	✓✓A A scaled drawing of an office viewed from above.	2A correct explanation (2)	MP L1 E
1.3.3	10 ✓✓A	2A correct no of people (2)	MP L1 E
1.3.4	False ✓✓A	2A correct answer (2)	MP E L1
		[20]	

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QUESTION/*VRAAG* 2 [27 MARKS/*PUNTE*]			
Q/*V*	**Solution/*Oplossing***	**Explanation/*Verduideliking***	**T/L**
2.1.1	557 km ✓ ✓RT	2RT correct distance **NPU** (2)	**MP** **L1** **E**
2.1.2	C ✓ ✓A	2A correct answer (2)	**MP** **L2** **M**
2.1.3	✓✓RT N3	2RT correct answer (2)	**MP** **L2** **E**
2.1.4	Pietermaritzberg ✓ ✓A	2A correct answer (2)	**MP** **L1** **E**
2.2.1	(a) B ✓A (b) A ✓A (c) R ✓A	3A correct answer (3)	**MP** **L2** **E**
2.2.2	$\frac{1}{8}$ ✓ ✓A	1A numerator 1A denominator (2)	**MP** **L2** **E**
2.3.1	NE East of North ✓ ✓A	2A correct direction (2)	**MP** **L2** **E**
2.3.2	The scale enlarges or reduces with the map. ✓ ✓A	2A correct explanation (2)	**MP** **L2** **E**
2.3.3	Measured Bar scale = 4,3 cm ✓A 4,3 cm = 125 km ✓MA 4,3 cm = 12 500 000 cm ✓C 1 : 2 906 976,744 ✓CA NB: **Check the measurement on the final paper**	(±1) 1A Measured value. 1MA equating to 125 1C conversion 1CA correct answer (4)	**MP** **L3** **E**

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2.3.4	Measured distance = 5,6 cm ✓A $\frac{5,6 \times 2\,906\,976,744}{100\ 000}$ ✓MA ✓C = 162,79 km ✓CA Reading from table 170 km ✓RT He is correct ✓O	1A measured value ((±1) 1MA using the no scale 1C conversion 1CA correct answer 1RT correct distance 1O Conclusion (6)	**MP L4 M**
		[27]	

QUESTION/*VRAAG* 3 [24 MARKS/*PUNTE*]			
Q/*V*	**Solution/*Oplossing***	**Explanation/*Verduideliking***	**T/L**
3.1.1	A = s× s = 42 cm × 42 cm ✓ SF = 1764 cm² ✓A	1SF correct substitution 1A correct answer (2)	M L2 E
3.1.2	42 cm – 40 cm ✓MA = 2 cm ✓A 2 ÷ 2 = 1 cm✓A	1A subtraction 1A correct answer 1A correct answer (3)	M L2 M
3.1.3	V = **3,142 × radius²× height** ✓A ✓C = 3,142 × $(\frac{40}{2})^2 \times (\frac{20}{10})$ ✓SF = 2513 ,6 cm³ ✓CA	1A radius 1C conversion 1SF correct substitution 1 CA (4)	M L2 M
3.1.4	A = $\frac{3,142\ x\ radius^2}{8}$ ✓SF = $\frac{3,142 \times (20)^2}{8}$ ✓MA = 157 , 1 cm²	1SF correct substitution 1MA dividing by 8 (2)	M L2 E
3.2.1	**Perimeter = 2 × (length + width)** = 2 (8 feet + 6 feet) ✓ SF = 28 feet ✓ CA	1SF correct values 1CA answer (2)	M L2 E

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3.2.2	Length = 8 feet – (2×1) = 6 feet ✓MA ✓A Width = 6 feet – (2×1) = 4 feet ✓A Height = 5 feet – 1 foot = 4 feet ✓A	1MA subtracting the thickness. 1A answer 1A answer 1 A (4)	M L3 M
3.2.3	**Volume = Length × Width × Height** = 6 feet x 4 feet x 4 feet ✓MCA = 96 feet^2 ✓ CA✓ A	**CA from 3.2.2** 1MCA substitution 1CA answer 1A unit (3)	M L2 E
3.2.4	SA = **(length × width) + 2 (length × height) + 2 (width × height)** = (6 x 4) + 2 x (6 x 4) + 2 x (4 x 4) ✓SF = 24 + 48 + 32 = 104 feet^2 ✓CA 1,785 l = 65 feet^2 104 feet^2 will need 2,785 l ✓CA OR 3 l will cover the area of 109,24 feet^2 Statement is valid ✓O **Using outside dimensions 3/4**	1SF correct values 1CA answer 1CA no of litres/area 1O Conclusion (4)	M L3 M
		[24]	

QUESTION/*VRAAG* 4 [29 MARKS/*PUNTE*]			
Q/*V*	**Solution/*Oplossing***	**Explanation/*Verduideliking***	**T/L**
4.1.1	42 ÷ 0,264172 ✓MA = 158,98 l ✓ CA = 159 l ✓R	1MA dividing correct values. 1CA answer 1 R rounded value (3)	M L2
4.1.2	30 000 × 0 , 264172 ✓MA = 7 925 , 16 gallons ✓ CA ∴ 7 925 ,16 gallons ÷ 42 gallons ✓MCA = 188 ,69 ✓ CA He is correct ✓O	1MA multiplying correct values. 1A no of gallons 1MCA diving by 42 1CA answer 1O conclusion	M L3 M

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	✓A ✓✓A 30 000 ÷ 158,98 = 188,69 ✓CA He is correct ✓O	1A numerator 2A denominator 1CA answer 1O conclusion (5)	

4.1.3	✓MA 1 398 km ÷ 100 = 13,98 ✓A 13,98 × 24 = 335,52 ℓ ✓CA 335,52 ℓ × R 20,20 / ℓ ✓MCA = R 6 777,50 ✓CA ∴ R6 777,50 × 2 = R 13 555,00 ✓CA Incorrect ✓C	1MA dividing by 100 1A answer 1CA answer 1MCA multiplying with the rate R 20,20/ℓ 1CA answer 1CA 1O Conclusion (7)	M L3 D
4.1.4	Distance = Speed x Time ✓SF 1398 km = 80 km/h x time ✓MA Time = 1398 km ÷ 80 km/h ✓CA = 17,475 hours + 60 min (1 hour) = 18,475 ✓MCA = 0,475 x 60 = 28,9 = 29 minutes ✓C = 18 hours and 29 minutes Arrival time = 10:30 + 18 hours and 29 minutes ✓MCA = 04:59 the following day ✓CA	1SF correct substitution 1MA changing the subject 1CA answer 1 MCA hours 1C conversion 1MCA addition 1CA time of arrival (7)	M L3 M
4.2.1	Two exits ✓✓A	2A correct no of exits (2)	MP L2 E
4.2.2	48 ✓✓A	2A correct number of seats (2)	MP L1 E
4.2.3	✓A ✓A She must move to the right pass F6 and then turn left, then continue straight towards row R . R24 will be on the left . ✓A	1A Pass F6 1A Turn left 1A R24 will be on the left (3)	MP L2 M
		[29]	

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Appendix L: Addendum for June exam question paper

education

Department of Education
FREE STATE PROVINCE

GRADE 12

MATHEMATICAL LITERACY

PAPER 2

JUNE 2024

ADDENDUM

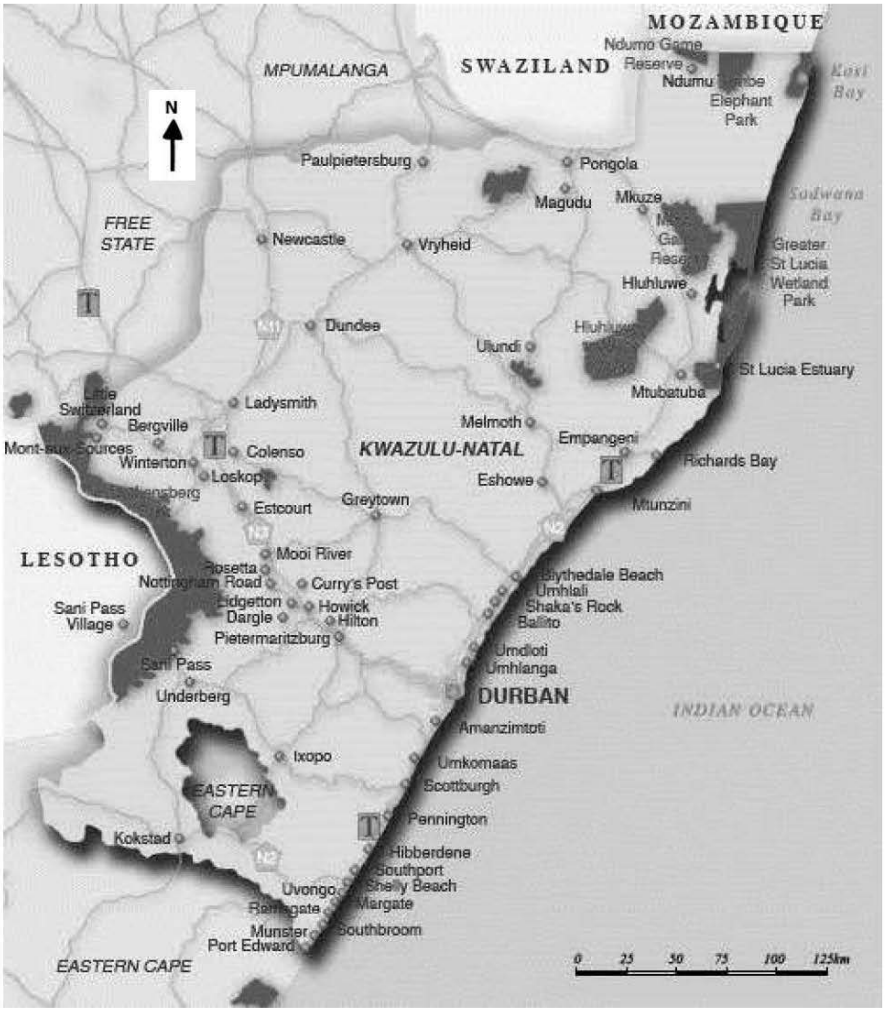
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ANNEXURE A

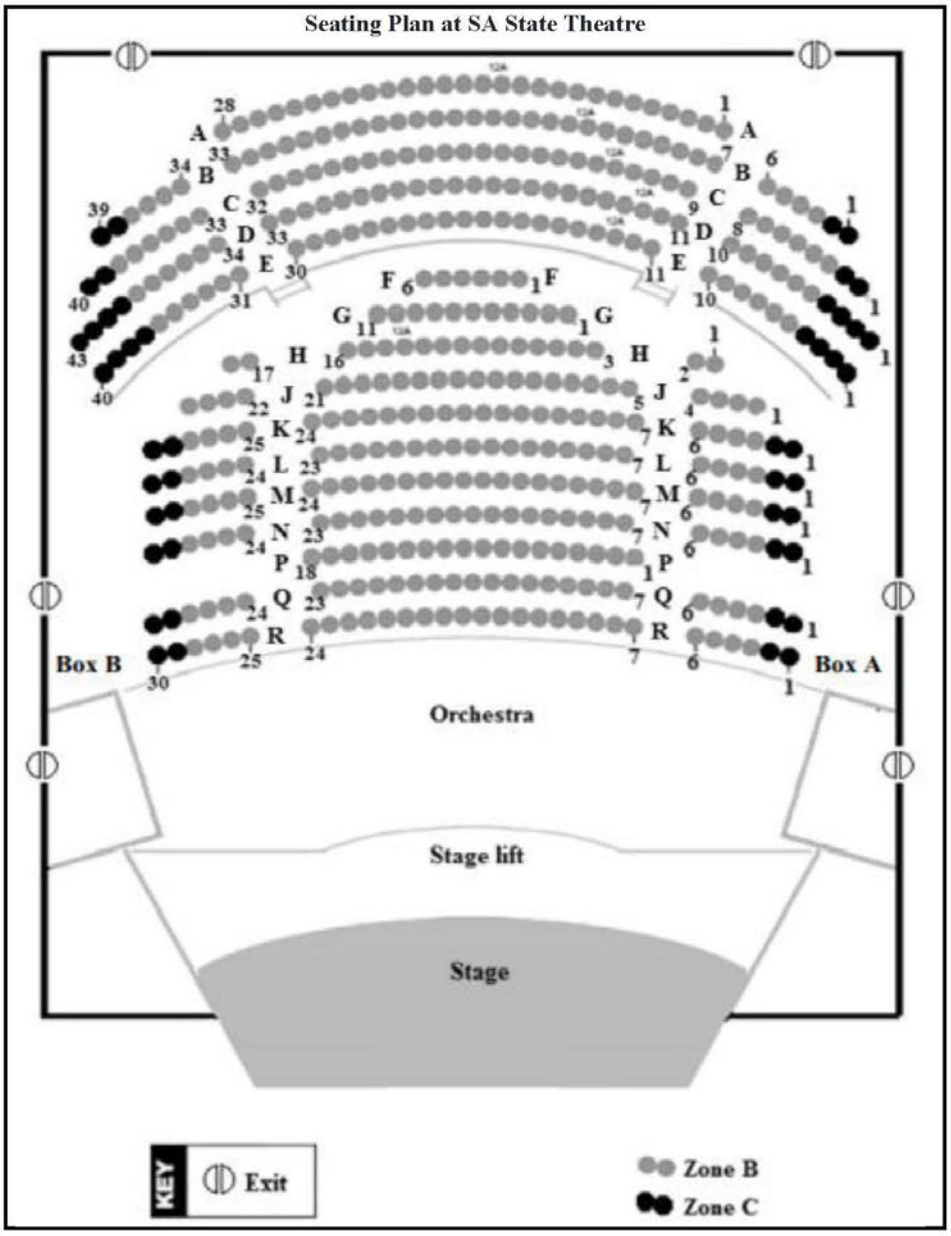
QUESTION 2.3

KZN MAP



ANNEXURE B

QUESTION 4.2



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Appendix M: Letter from the editor

CERTIFICATE
OF PROFESSIONAL EDITING

I, Barbara L. Louton, declare that I am a professional editor with a Bachelor of Arts in Professional Writing, a Master of Arts in Development Administration, and 20 years of experience as an editor, researcher, and writer.

I declare that I was contracted by **Lebohang Victoria Mulaudzi, a doctoral candidate at the University of KwaZulu-Natal,** to complete a professional edit of her manuscript:

Mathematical Literacy teachers' strategies to engage with learners' misconceptions and errors in the teaching of Measurement in Grade 12.

I declare that I have completed a two-stage professional edit of the document. The edit addressed issues with the logic, structure, language, style and formatting of the manuscript. Changes were tracked and comments were made in text with recommendations for the client to address.

Disclaimer:
Responsibility for the originality and accuracy of the material presented in the manuscript lies with the author. I have not verified the originality or accuracy of statements, quotations or citations and references presented in the manuscript. Where I have detected inaccuracies, I have rectified them or reported them to the author. Please note that the author was free to make further changes to the manuscript after the edit.

I can be contacted at:
Cell: [redacted]
Email: [redacted]

Barbara L Louton	[redacted]	11 November 2025
Name	Signed	Date

Appendix N: Turnitin report



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