

https://dspace.org/

Exploring the Nature of Grade-8 Classroom Environments Created by Mathematics Teachers when Teaching Mensuration: A Case of Curriculum Implementation in Lesotho

Raphoka, Sikeme

2024
University of the Witwatersrand, Johannesburg
https://hdl.handle.net/10539/45037

Raphoka, Sikeme. (2024). Exploring the Nature of Grade-8 Classroom Environments Created by Mathematics Teachers when Teaching Mensuration: A Case of Curriculum Implementation in Lesotho [PhD thesis, University of the Witwatersrand, Johannesburg]. WIReDSpace. https://hdl.handle.net/10539/45037

Downloaded from a DSpace repository. https://dspace.org/

Exploring the Nature of Grade-8 Classroom Environments Created by Mathematics Teachers when Teaching Mensuration: A Case of Curriculum Implementation in Lesotho

A thesis submitted to the Wits School of Education, Faculty of Humanities, University of the Witwatersrand in fulfilment of the requirements for the degree of Doctor of Philosophy

By

Sikeme Raphoka

Student number: 2422936

Ethics protocol number: H21/07/41

Supervisor: Dr. Batseba Mofolo-Mbokane

2024

DECLARATION

I, **Sikeme Raphoka**, declare that the study, **Exploring the Nature of Grade-8 Classroom Environments Created by Mathematics Teachers when Teaching Mensuration: A Case of Curriculum Implementation in Lesotho**, represents original work by me as the author and has not been submitted in any form to another university for assessment. Where the work of others has been used, this has been duly acknowledged in the text and a reference list has been provided. I fully understand that the University of the Witwatersrand will take disciplinary action against me if evidence suggests that this is not my own work or that I failed to acknowledge the sources of the ideas or words of others in my writing.



Sikeme Raphoka

Date: 20 September 2024

ABSTRACT

This study explores the types of classroom environments created by mathematics teachers as they implement the integrated curriculum in Grade 8 classrooms in Lesotho, thus calling for Learner-Autonomous Environments (LAE) with particular focus on Mensuration. This is a qualitative study and data was collected from four Grade 8 mathematics teachers from four high schools in Maseru district. The teachers were purposively selected from the four schools to participate in the study based on characteristics such as their teaching experience, qualifications and whether they were teaching mathematics at Grade 8. Groups of four learners were selected in each teacher's class through the help and preference of each teacher, making a total of sixteen learners targeted for group discussions data. Data was collected through classroom observations (whole class and focus groups observations) and teachers' interviews. Before the data collection commenced for the main study, two mathematics teachers were purposely selected from two other schools for the Pilot study. Using a LAMLE conceptual framework, formulated from the theories, Commognitive theory (Sfard, 2008) and Pedagogical link-making (Mortimer & Scott, 2003) and Communicative approach (Scott *et al*., 2011), literature and curricular expectations, the study analysed both the Pilot and main study data to come up with the findings.

Presented in three main themes, the findings indicate that though all the teachers were operating differently at the deeper performance level, they all dominantly used direct instructional approach, performed ritual teaching routines and dominated the link-making discussions through the use of interactive/authoritative communicative approach. Learners were also found to be lacking in terms of conceptual understanding, problem solving, and computational accuracy. They were also observed to be performing ritual routines mostly in their learning process. It is concluded that teachers seem to know what is expected of them but fail to implement it as expected in terms of the Lesotho curriculum. It is further concluded that learners have been denied the opportunity to be autonomous in their mathematics learning. The study proposes a LAMLE+ Plus model, formulated based on findings on the teachers and in terms of the established themes, for studying the promotion and presence of LAE in mathematics teaching. The model also advances as a tool to direct the practices and focus of teachers and education administration when implementing the reformed curriculum which focuses on learners' active conceptual development and progressive autonomy as highlighted by Lesotho's CAP

It is recommended that teachers take time to understand the expectations of the curriculum and execute their classroom practice accordingly, especially the proposed instructional approaches and learner engagement. It is also recommended that the Ministry of Education and Training (MoET) provide teachers with capacitation workshops towards the implementation of the curriculum and closely monitor their progress as facilitation of change from traditionally-oriented practices to reform-oriented practices.

Keywords: Mensuration, learner autonomy, curriculum implementation, classroom environment, teachers

ACKNOWLEDGEMENTS

I am greatly indebted to a number of people for their support and diligent guidance throughout this research work. First I would like to express my deepest gratitude to Dr. Batseba Mofolo-Mbokane, my PhD research Supervisor. Not only was she inspiring as an educator and an academic but she also extended her full support academically and psychologically throughout the process to the very final writing of this thesis. Without her expertise, understanding, patience, sense of humour and positive attitude, the completion of this research study would have not been feasible. I found her suggestions valuable and criticisms greatly constructive. Thank you for the encouragement and the support when I most needed it.

My heartfelt thanks go to all the students and teachers who voluntarily took part in this study, and the school principals for allowing me to carry out my study in their schools. Without your understanding and participation, this study would have not been possible.

My deepest thanks go to my loving family:

- To my loving wife, 'Mabafokeng, you have been my pillar and my rock throughout this journey. Thank you for supporting me throughout all the stages of my study. Your prayers, unconditional love, support, endless encouragement, patience and understanding, and your confidence in me have continually driven me to persevere and pursue my ultimate goal. Thank you for enduring, both emotionally and physically, and for being patient with me from the start to the completion of this study. I cannot imagine having successfully come this far without you. Thank you and thank you once again.
- To my lovely daughter, 'Machaka, thank you for bothering me continuously with your endless demands, curious questions and concerns. You really kept reminding me of my responsibility as a father. Your love, laughter and jokes kept me happy and healthy both mentally and emotionally. I rest assured that there is more where that came from.
- To my mother, 'Masikeme, and my laid father, Sehlahla, thank you for raising me into a man that I am now, for nourishing my soul with your words, both hush and tender. All these and all, have duly prepared me for the hardship I was yet to experience and the endurance I had to maintain in this work and all things in my life. For teaching me to always love, fear and pray God in good and hard days, KEA LE LEBOHA BAFOKENG.

I would like to further express my sincere thankfulness to all my friends, in particular Ms 'Macheli and Mr Khobotle, for being around me for emotional support and motivation when I

needed courage. Through this support you immensely sharpened my focus and thinking as I progressed with the study. Your words of encouragement, time spent around me, and emotional support when I most needed a hand, will remain in my mind forever.

Finally, I am grateful to my colleagues at work, in particular the NUL Department of Science Education. Thank you for supporting me through my endless research-based questions and spontaneous peer debriefing sessions. Your linguistic, research-based, and technological expertise, intertwined with a sense of humour, understanding, selflessness and avidity to help, have contributed greatly in my courage and perseverance throughout the study and thus successful completion. You were my source of energy, my home away from home and my support system. I will always carry you all in my heart. Thank you!

I am so grateful to God Almighty for making all this possible.

Table of Contents

Table of Contents

DECLARATION ii

ABSTRACT iii

ACKNOWLEDGEMENTS v

Table of Contents vii

LIST OF ABBREVIATIONS x

INDEX OF TABLES x

INDEX OF FIGURES x

Chapter 1: Introduction and Background 1

1.0 Introduction 1

1.1 Background 2

1.2 The Curricular Expectations 3

1.3 Rationale 5

1.4 The Problem Statement 6

1.5 Research Questions 8

1.6 Overview of Chapters 10

Chapter 2: The Literature Review 12

2.0 Chapter Overview 12

2.1 Active Instructional Approach and Direct Instructional Approach 12

2.2 Mathematical Discourses and Routines - Dialogical Nature of mathematics Classroom 17

2.3 Active Teaching and Learning of Mensuration and Learner Competences 18

2.4 Effective mathematics Learning Strategies and Learner Competences 21

2.5 Classroom Interactions in mathematics Education 23

2.6 Pedagogy - Role of the Teacher 24

2.7 Learner-Autonomy in mathematics Teaching and Learning 25

2.8 Conclusion 27

Chapter 3: The Conceptual and Theoretical Frameworks 30

3.0 Introduction 30

3.1 The Theoretical Frameworks 31

3.2 The Learner-Autonomous Mathematics Learning Environment (LAMLE) Framework 46

Table. 4 Mapping parts of LAMLE framework and the Sub-Research Questions 48

3.3 Conclusion 49

Chapter 4: Research Methodology 51

4.0 Introduction 51

4.1 Research Design 51
4.2 Population and Sampling 52
4.3 Instrumentation 56
4.4 Data Collection Procedures 58
4.5 Data Processing and Analysis 60
4.5.5 Data Presentation and Thematic Presentation of the Findings 64
4.7 Ethical Considerations 67
4.8 Conclusion 68
Chapter 5: The Pilot study 70
5.0 Introduction - What was proposed 70
5.1 Methodology 70
5.2 Ultimate changes resulting from the Pilot 81
5.3 Conclusions on the Pilot Study 81
5.4 Overview and Introduction of the Data presentation and analysis Chapters 82
Chapter 6: Data Presentation and Analysis 1– The Case of Nthabi's Class 84
6.1. Nthabi's Instructional Practices 84
6.2 Learner competences, classroom discourses and routines 115
6.3. Nthabi's responses to the Interview Questions - Teacher's understanding of her role 127
6.4. Summary of Nthabi's instructional approaches and data consolidation (interview responses vs observed actions) 131
6.5. Conclusion 134
Chapter 7: Data Presentation and Analysis 2 – The Case of Teko's Class 136
7.1. Teko's Instructional Practices 136
7.2 (Episode 3, Lesson 2) Learners' Competence, Classroom Discourses, Routines and Interactions 149
7.3. Teko's responses to the Interview Questions - Teacher's understanding of his role 158
7.4. Teko's Data Consolidation - Interview Responses Vs Observed Actions 163
7.5. Conclusion 166
Chapter 8: Data Presentation and Analysis 3 – The Case of Nkoe's Class 170
8.1. Nkoe's Instructional Practices 170
8.2 Learner competences, classroom discourses, routines, and interactions 197
8.3. Nkoe's responses to the Interview Questions - Teacher's understanding of his role 207
8.4. Summary of Nkoe's instructional approaches and data consolidation (interview responses vs observed actions) 214
8.5. Conclusion 216
Chapter 9: Data Presentation and Analysis 4 – The Case of Pita's Class 220

9.1. Pita's Instructional Practices 220
9.2 Learners' competences, classroom discourses and routines 230
9.3. Pita's responses to the Interview Questions - Teacher's understanding of his role 233
9.4. Pita's data consolidation - interview responses vs observed actions 239
9.5. Conclusion 241
Chapter 10: Thematic Presentation of the Findings 245
10.0 Introduction 245
10.1 Theme 1: Pedagogical Practices (The Observed, Implied and Perceived) 245
10.2 Theme 2: Learner-Learner Discourses and Routines, and Competences in Mensuration 252
10.3 Theme 3: Teachers' Role in Curriculum Implementation 254
10.4 Conclusion – Classroom Environment and Opportunities for Learner Autonomy 255
Chapter 11: Interpretation and Conclusion 258
11.0 Introduction 258
11.1 Overview of the present Study 259
11.2 Addressing the Study's Sub-Research-Questions 260
11.3 Addressing the Main Research Question 287
11.4 Recommendations of the study 293
11.5 Limitations of the Study and Suggestions for Further Research 296
REFERENCES 299
APPENDICES 307
Appendix A 307
Appendix B 308
Appendix C 310
Appendix D 311
Appendix E 312
Appendix F 314
Appendix G 316
Appendix H 317
Appendix I 318
Appendix J 319
Appendix K 323
Appendix L 313
Appendix M 316
Appendix N 317
Appendix O 318

LIST OF ABBREVIATIONS

CAP	–	Curriculum and Assessment Policy
LAE	–	Learner-Autonomous Environment
LA	–	Learner-Autonomy
MoET	–	Ministry of Education and Training
OBE	–	Outcomes-Based Education
RPL	–	Recognised Prior Learning
AML	–	Autonomous Mathematics Learner
LAMLE	-	Learner Autonomous Mathematics Learning Environments

INDEX OF TABLES

Table. 1 The Curricular Aspects Linked to the Problem Statement…… 4

Table. 2 Comparing Rituals and Explorations…… 35

Table. 3 Four Classes of Communicative Approach……45

Table. 4 Mapping parts of LAMLE framework and the Sub-Research Questions…… 48

INDEX OF FIGURES

Figure 1. The LAMLE Framework……..47

Figure 2. Example of analysis notes writing and coding…….62

Figure 3. The Proposed Analytical Framework (old version) ……..74

Figure 4. Learners scrapping the floor and plugging ‘poles’ to mark their ‘sites’…… 173

Figure 5. Teacher demonstrating to Mosa…… 174

Figure 6. The LAMLE+ Plus model for study of LAE and Practical direction into curriculum implementation…… 292

Chapter 1: Introduction and Background

1.0 Introduction

In Lesotho's education system, developing actively engaged and autonomous learners is one of the radical goals proposed by the Ministry of Education and Training (MoET, 2009). This goal was braced by the introduction of an integrated curriculum which advocates for learner-autonomous environments (LAE), viable concept development, and radical learner-participatory teaching strategies (MoET, 2017). This was a timely educational reform in accordance with education systems of recent times which recommend learner-centred strategies and promotion of learner autonomy (LA) (Nakata, 2011). The concept of learner autonomy has long been conceptualised as the learners' capability to take control of their learning process, which is attributed to their ability to function independently, undertake critical reflections and decision-making to monitor their development (Holec, 1981; Little, 1991). In line with the MoET elaborative curricular goals, research focusing on learner-autonomous environments insists that LA provides learners with developmental opportunities such as strengthening critical thinking and good achievement (Khurshid, 2017).

In the context of Lesotho education system, the country's new integrated curriculum arose as a present and future remedy for the prevalent underperformance in most subjects, such as Mathematics, Physical Science, Biology, Inclusive Education and other school level subjects, and to phase out the old curriculum which had limiting factors (including lack of integration among subjects and between subjects and real-life matters) (MoET, 2009). The curriculum was further accused of its implicitness on learner-centred teaching strategies, learners' underperformance and lack of conceptual understanding due to prevailing teacher-centred methods (Examinations Council of Lesotho (ECOL), 2018; Nts'asa & Machaba, 2019).

One particular example is that learners were reported to be underperforming and showing lack of conceptual understanding in Mensuration-related higher order questions (Nts'asa & Machaba, 2019). The present study thus aimed at exploring the nature of Grade 8 classroom environments created by mathematics teachers on implementation of the integrated curriculum. This included looking into how autonomously and actively learners were engaged throughout their learning process, and if the teacher created enough opportunities for learners to be engaged autonomously and actively. Influenced by the proposed curricular aspects, the study

assumed that different classroom environments (including instructional approaches) promote different classroom routines and discourses, and diversity in the way learners understand mathematics concepts such as Mensuration. Hypothetically, LAE were expected to promote more formal and mathematics-focused discourses and enhance learners' understanding of Mathematical concepts.

1.1 Background

The move to introduce innovative and learner autonomous instructional environments has always been a preferred educational approach to education globally (for example, a study by Linneweber-Lammerskitten, Schäfer & Samson, 2010). Learner autonomy is considered to allow learners freedom and promote self and collaborative motivation. It is however necessitated by the teachers' provision of opportunities which nurture learners' independence (Lamas, Maria & Gomes, 2010).

Though I was not optimistic that the real classroom situations in Lesotho schools allow this kind of teaching-learning environments, it was important to explore whether teachers have the same point of view as the rest of the world on LAE. This includes how LAE influence certain types of discourses among learners. However, taking this innovative move could be beneficial or rather detrimental to the learner-outcome if not cautiously undertaken. For instance, Reinders and White (2011) warned that if learners are not provided with proper guidance and feedback or progress report, their unrestricted access to resources and information could inhibit them from being responsible for their learning, thus hindering their development as autonomous learners. This implies that though LAE are recommended for learners to elicit their academic development, teachers should adequately exercise their authority to monitor and guide learners.

As one of the Curriculum and Assessment Policy (CAP) (MoET, 2009) prescribed strategies, an active instructional approach to teaching and learning has not been a commonly practised or easily implemented phenomenon in actual classrooms in Lesotho and other countries. For instance, in South Africa, the implementation of active learner-centred approaches such as outcomes-based education (OBE) and recognised prior learning (RPL) were reported to have been hindered by time limits; inadequate or inferior professional training; overcrowding; and the inadequate supply of facilities and resources (Motseke, 2005; Cretchley & Castle, 2001).

Research on Lesotho classroom teaching shows that a number of factors hindered implementation of teaching strategies which could maximise learners' active engagement. These included teachers' lack of pedagogical knowledge, limited time and the 'learner characteristics' (Qhobela & Moru, 2014). In some instances, teachers were reported to have verbally uttered correctly what they needed to do in implementing learner-centred methods yet it never reflected in their classroom teaching due to their tradition of chalk-and-talk teaching methods (Qhobela, 2012). As such, looking into how teachers interact with learners during classroom teaching of Mensuration informed the study on the pedagogical knowledge of teachers on this topic and shed light on how they understand their role as prescribed by the curriculum. It could also have implications for the adequacy of professional development teachers received prior to implementation of the curriculum.

The learners' success in concept development of Mensuration at any education level is a function of the learning opportunities made possible by the teaching approaches utilised (Tunji-Olayeni, Kajimo – Shakantu, Ayodele & Emmanuela, 2021). The learners' failure to comprehend the Mensuration concepts is pinned on usage of teacher-centred methods; lack of opportunity for learner participation; insufficient examples; lack of use of concrete materials and technological resources, during the teaching of these concepts (Tunji-Olayeni *et al.*, 2021), practices which mostly imply lack of active instructional approach and LA. The learners' demand of learner-centred approaches in learning Mensuration is probably influenced by the practical nature of this topic which requires practical engagement and manipulative skills. These skills can therefore benefit from a classroom environment which allows LA and collaborative discourse on the major concepts of the topic. This perspective reveals the motivation for the choice of Mensuration as an appropriate topic to study LAE, the discourses and learner academic development that result from such environments.

1.2 The Curricular Expectations

Table 1 shows the curricular constructs adopted from CAP and the Grade 8 mathematics syllabus, classified as: *Learner Core Competencies; Pedagogy; Learner Autonomy;* and *Learners' Skills in Mensuration*. According to MoET (2009) learners' core competencies "indicate the capabilities which learners acquire as they go through the education system at different levels" (p.5). The competencies are listed as descriptors in the table. The pedagogy is recommended to "shift more towards methods that develop creativity, independence and survival skills of learners" (p.6). As stated in the Grade 8 syllabus (MoET, 2017), the curricular

materials are organised to prepare learners to be autonomous and advocate active and independent learning.

In the present study, special attention is drawn towards Mensuration. As shown on the table, learners are envisioned to be equipped with a number of skills when learning Mensuration. In this study, I consider the Learner Core Competencies and Pedagogy as the *main constructs* while Learner Autonomy and Mensuration Skills as *embedded* constructs. The embedded constructs are articulated by the syllabus which is a document designed to implement the CAP. This implies that Learners' Mensuration skills and Learner autonomy can be observed when learners are engaged in the development of the core competencies through communicative discourses and written work on problem solving.

Table 1. The curricular Aspects Linked to the Problem Statement

CURRICULAR ASPECTS [Adopted from Curriculum and Assessment Policy (CAP) and Grade 8 Syllabus (MoET, 2009; 2017)]			**Links to Problem statement**
Curricular document	**Curricular Construct**	**Descriptors**	**Units of observation**
CAP	Learner Core Competencies	Effective and functional communication, and Problem solving Scientific, technological and creative skills Critical thinking skills Collaboration Functional numeracy	**Learner Competence**
	Pedagogy	Shift from didactic to methods that develop creativity, independence Teachers play facilitative role Teachers use of active instructional approaches vs direct Participatory, activity-centred and interactive methodologies	**Pedagogical Practices** *Instructional Approaches (Active v Direct)* *Discourses and routines* *Teacher-learner Interactions*
SYLLABUS	Learner Autonomy	Learners become more autonomous under certain pedagogical practice Learners assume greater responsibility for their learning Active and independent learning	**Pedagogical Practices** *Instructional Approaches (Active v Direct)* *Discourses and routines* *Teacher-learner Interactions* **Learning Practices** *Discourses and routines* *Teacher-learner Interactions* **Learner Competence**
	Mensuration Skills	Accuracy and estimation General manipulations (concrete to abstract material) Measurement and calculation of lengths of sides, Perimeter, and Area of 2D shapes	**Learner Competence**

In the above table, the first major column (CURRICULAR ASPECTS) shows the constructs (second column) selected from the curricular documents (first column) CAP and Grade 8 mathematics syllabus. Each of these constructs are described with descriptors (third column) which are detailed by the related document as a guide for observation of these curricular constructs. The second major column (Links to Problem statement) shows the Units of observation for the study which guided the formulation of the problem statement. Each of these units align with the curricular constructs and the research questions are selectively classified under each, hence they drive the focus of the study.

Drawing from these curricular aspects, I postulate that successful mathematics learning (especially of Mensuration content) requires learner-autonomous classroom environments, focused on a network of connected concepts that help shape learners into knowledgeable autonomous mathematics learners (AMLs).

1.3 Rationale

This study was provoked by: (1) the experience I had around the implementation of the integrated curriculum; my long experience in setting and marking Junior Certificate (JC), Cambridge Overseas School Certificate (COSC) and Lesotho General Certificate of Secondary Education (LGCSE) mathematics examinations; and (2) literature on learner-centred teaching approaches in Lesotho classrooms and internationally.

I realised that Grade 8 learners' conduct was unusual during mathematics lessons compared to learners in other grades (higher grades which were still called Forms B, C, D and E, from old COSC curriculum). During informal discussions with their teachers, these learners were referred to as 'active'. Therefore, they were allowed (by their teachers) to freely communicate with each other and move around the classroom chaotically during the mathematics lessons.

Through CAP, MoET proposed that the classroom teaching environment should be learner-autonomous and promote active instructional approaches to teaching and learning. Learners were therefore expected to "assume a greater responsibility for their learning" (MoET, 2009, p.6), while teachers play the role of active learning facilitators. This lack of harmony between the curricular expectations and actual classroom experience during the implementation of the curriculum aroused my curiosity on how teachers understand the curricular-proposed LAE, active instructional approach and their role in these environments.

Mensuration is widely applied in fields such as civil engineering measurement (Tunji-Olayeni *et al.*, 2021). However, from my examinations marking experience of over 14 years, I noticed that most candidates failed to obtain full marks on Mensuration questions (which constituted about 35% of each examination paper). Further, concepts in Mensuration, such as Area, Perimeter and Volume, use pre-existing formulae and working procedures, but could also be learned through the use of practical work with concrete materials, and explorative strategies, if conceptual understanding was to be pursued. Due to this observed underperformance and the practical nature of Mensuration, studying the implementation of curriculum during classroom teaching of Mensuration concepts may show whether LAE and active learning are possible and appropriate to enhance learners' understanding in the Lesotho classroom situation. It may further reveal the teaching diversity with respect to teaching for conceptual understanding as opposed to rote procedural performance on each concept.

In the context of Lesotho secondary school education, Qhobela and Moru (2014) found that the implementation of learner-centred methods encountered a number of hindrances including: unavailability of time and resources; learner characteristics; and teachers' lack of pedagogical knowledge. However, these findings were gathered from a study with no focus on mathematics (especially Mensuration) teaching. Therefore, an exploration of the teaching approaches, discourses and routines, used in implementing the curriculum, while teaching Mensuration, may reflect whether teachers have adequate pedagogical knowledge or whether they have been adequately capacitated to implement the curriculum, in this case the Lesotho curriculum.

Since the curriculum reached the secondary level (Grade 8) in 2019, and during my literature search for the current study, I have not come across a reported research study on the implementation of these curricular-proposed teaching-learning environments and approaches, and their influence on learners' development of concepts and proposed competencies. Since the idea of LAE (and active instructional approach) is a radical concept in the Lesotho secondary education, exploring how teachers facilitate it can be an eye-opener on teachers' readiness to change from traditional didactic teaching methods to more learner-participatory and autonomous environments.

1.4 The Problem Statement

Lesotho's Ministry of Education and Training (MoET) introduced an integrated curriculum which aimed at promoting learner-autonomous classroom environments (LAE). These environments are construed as promoting active instructional approaches to learning and allowing learners to "assume a greater responsibility for their own learning" (MoET, 2009, p.6). Learners are envisioned to develop the ability to identify, formulate, solve problems by themselves and evaluate their learning progress.

MoET's perspective on the classroom environment aligns closely with Little's (2003) definition of LA, which emphasises learners' understanding of the purpose of their learning programme and taking responsibility for their own learning process. In the context of mathematics learning, Warfield, Wood, and Lehman (2005) describe LA as the ability of learners to think about mathematical concepts without relying solely on explicit teacher explanations and to solve mathematical problems independently, without being explicitly taught the methods to follow. Due to the conceptual nature of LA, particularly in mathematics, the curricular proposed that active teaching-learning approach (the active approach) can be beneficial. This approach is characterised by a classroom environment that promotes interaction between learners and between learners and teachers through lively teaching-learning strategies (Petersen & Gorman, 2014). Such an environment should also provide opportunities for learners to engage in mathematics tasks that require deep cognitive engagement, allowing them to construct meaning, develop conceptual understanding, and make connections between different concepts (Bjørkestø, Borge, Goodchild, Nilsen & Tonheim, 2021).

However, research on classroom teaching in Lesotho has shown that teacher-centred strategies dominated most lessons (Qhobela & Moru, 2014). Furthermore, teachers did not facilitate conceptually productive learner discussions or provide sufficient guidance to learners in making meaning through classroom talk (Qhobela & Moru, 2020). Therefore, little was known regarding how successfully teachers were implementing LAE, especially in their mathematics classrooms, since it was a new and reform-oriented concept in Lesotho's education system.

Further, from my experiential observation, mathematics teachers and learners seem to have a rather diverse interpretation of the MoET's proposed curricular expectations, especially the LA and active instructional approach to learning. During mathematics lessons, these learners chaotically move (and are allowed to) around the classroom and communicate randomly. The

latter observation therefore does not show any inheritance of the characteristics of LA described above.

Furthermore, in informal discussions with the mathematics teachers (my colleagues –who were not participants in the present study) which happened prior to commencement of the current study, my anecdotal claim above was intensified by the teachers' reference to these learners as 'active', hence having to behave as they did, 'as stated by the curriculum'. Given the discussion herein on the conceptual nature of LA and the then research-reported teachers' instructional practices, and the above stated anecdote, the purpose of the present study was to explore the nature of Grade 8 classroom environments created by mathematics teachers as they implement the integrated curriculum, which calls for LAE and how that impacts on teaching and learning (that is, learners' competences development).

To implement the curriculum in classrooms, it is recommended that teachers facilitate active learning by "shifting from didactic teaching to participatory, activity-centred and interactive methodologies" (MoET, 2009; p.6). They are further advised to improvise and use concrete materials from learners' immediate environment; provide useful feedback to learners and reflect on their performance. As such, the study further sought to explore how teachers understand their role in the implementation of the LAE oriented curriculum. In executing research processes in this study, my expectation was that all the secondary education schools in Lesotho were implementing this LAE oriented curriculum accordingly. The study intended to explore what this LAE (if it did exist) could or could not bring to the learners' conceptual development.

1.5 Research Questions

The present study sought to address the main research question through five sub-questions.

Main Research Question:

What is the nature of Grade 8 classroom environments created by mathematics teachers as they implement the integrated curriculum, which calls for LAE (focusing on Mensuration)?

Sub-question 1: *What types of instructional approaches (active vs direct) do teachers use in Grade 8 classrooms?*

> The type of environment created by each teacher may be determined by the type of instructional approach used; whether active or direct instructional approach. Hence, the type of approach used can help determine the degree of learner autonomy provided to

learners. This can be determined from the observed classroom practices in each section of the lesson: How often the teacher gives learners opportunity to actively participate in the learning process, or whether the teacher provides all the explanations, definitions, formulae, computational procedures, and worked examples for each concept under discussion.

Sub-question 2: *What types of discourses and routines exist in these environments, when teaching or learning Mensuration?*

The type of instructional environment created by each teacher can also be described by the types of discourses (whether formal and mathematical or fully colloquial, and whether fully objectified or non-objectified) and routines (whether explorations or rituals) that exist between the teacher and the learners and amongst the learners themselves during the teacher's presentations and during learners' discussions in each part of the lesson. As discussed in Chapter 2, these could be used to determine the level of autonomy learners were exposed to during each instructional proceeding. These could therefore be analysed from the observed teacher-learner and learner-learner discussions during the teaching and during learners' discussions as they work on the given activities or problems involving taught or learned concepts of Mensuration.

Sub-question 3: *How do these types of classroom discourses and routines relate to how learners understand Mensuration concepts (learners' competences)?*

The teaching and learning of Mensuration concepts, Perimeter and Area, involve explanations or discussions of definitions, formulae, units, computational procedures and may involve problems for which the solutions need thorough understanding of these, and the concept as a whole. Therefore, learners' ability to solve the problems which involve these aspects may reflect their conceptual understanding which is brought by their exposure to the type of instructional or learning environment they are exposed to. This can be analysed from the learners' talk (discourses) and actions (routines) as they work on given activities and problems. The outcome of such analysis therefore could determine the learners' competence in problem-solving skills, and engagement in objectified discourses and explorative routines.

Sub-question 4: *How do teachers and learners interact during the teaching and learning of Mensuration concepts (Perimeter and Area)?*

The way in which the teacher interacts with learners during his explanations or discussions may help in describing the type of instructional or learning environment learners are exposed to. Studying these interactions could further determine if such environment offered learners enough opportunities to be autonomous in their learning. These interactions could be analysed from the teacher-learner conversations during the teaching process where explanations are required for elucidation of the concept under discussion.

Sub-question 5: *How do the Grade 8 mathematics teachers understand their role in implementation of LAE oriented curriculum in teaching Mensuration?*

The teacher's understanding or perspective of their role in implementation of the curriculum can describe their readiness and capability to abide by its demands. This can be analysed from each teacher's observed dominant instructional approach, their most visible teaching routines, and their ways of interacting with learners, hence their observed likelihood of creating opportunities for learners' autonomous learning. This can also reflect in the way they verbally describe the expectations of the curriculum and their preferred instructional approach, and how they verbally describe their role from the observed lessons.

1.6 Overview of Chapters

In the light of the above research questions, I present the outline of the next Chapters. Chapter 2 discusses the literature related to the major themes guiding the study. Outlined throughout the chapter are: discussions in relation to definitions of LA and active engagement in a mathematics classroom; active instructional approach as opposed to direct instructional approach, and effective teaching/learning in mathematics education; classroom discourses and routines in mathematics teaching and learning; learner competences in relation to problem-solving and learning Mensuration concepts; and the teacher's role in promotion of LA; and interactions between the teacher and learners.

Chapter 3 outlines the conceptual framework and theoretical frameworks which guided the study structure and data analysis. Chapter 4 outlines the methodological aspects deployed throughout the study. Chapter 5 outlines the methodological processes undertaken to pilot the study's instruments, and the changes incorporated as a result. Chapters 6, 7, 8, and 9 present how teaching and learning occurred in each of the four teachers' classes, and the analysis on

each of the episodes. Chapter 10 presents the findings presented in the four preceding chapters in the form of themes which provide a preview into the discussions and interpretations chapter. Chapter 11 provides the discussion of the findings integrated from the preceding chapters. It involves linking such findings to existing literature, and discussion over the improved LAMLE conceptual framework which is proposed as a tool for studying and evaluating the LAE in mathematics classrooms in curricular-change contexts such as Lesotho.

Chapter 2: The Literature Review

2.0 Chapter Overview

This chapter presents the literature related to the title of the present study and the research questions. The literature is discussed in the following seven sub-sections:

2.1 *Active Instructional approach and Direct Instructional Approach*

2.2 *Mathematical Discourse and Routines- Dialogical Nature of mathematics Classroom*

2.3 *Active Teaching and Learning of Mensuration and Learner Competences*

2.4 *Effective mathematics Learning Strategies and Learner Competences*

2.5 *Classroom Interactions in mathematics Education*

2.6 *Pedagogy - Role of the Teacher*

2.7 *Learner-Autonomy in mathematics Teaching and Learning.*

2.1 Active Instructional Approach and Direct Instructional Approach

2.1.1 Direct Instructional Approach

For behavioural psychologists, learning means acquiring new behaviours, and new behaviours are learned because of the role that external stimuli play. Thus, a behavioural approach to teaching involves arranging and implementing those conditions that make it highly likely that a desired response will occur in the presence of a particular stimulus (such as reading a sentence fluently, accurately using the correct mathematical operations when faced with a long-division problem, and giving the correct English translation of a paragraph written in Spanish). Perhaps the most popular approach to teaching that is based on behavioural theory is direct instruction (Adams & Carnine, 2004, p.370).

The above paragraph lays a foundation to a most basic (to novice teaching professionals, such as pre-service and early service teachers) and conventional teaching approach known as Direct instructional approach (DI). For many centuries research failed to provide the exact and universal definition of direct instructional approach (for example, Rosenshine, 2008). In place of a universally agreeable definition, researchers from different generations produced characteristic descriptions of DI. Echoing and citing the writings of historical authors (such as Joyce & Weil, 2004; Rosenshine, 1987; and Rosenshine & Carla Meister, 1994), Adams and Carnine, (2004) outlined four characteristics of DI as:

1. Focusing almost all classroom activity on learning academic knowledge and skills, while ignoring or de-emphasising affective and social objectives such as improved self-esteem and learning to get along with others;
2. Having the teacher make all instructional decisions, such as how much material will be covered at one time, whether students work individually or in groups, and whether students work on mathematics during morning and social studies during the afternoon (that is, in a primary school classroom);
3. Keeping students working productively towards learning new academic knowledge and skills (usually called being on-task) as much as possible; and
4. Maintaining a positive classroom climate by emphasising positive reinforcement and avoiding the use of aversive consequences (p.370).

While on the same task of trying to highlight its distinguishing characteristics, Rosenshine (2008, p.2-4) came up with five overlapping 'meanings' to DI. These are: 1. Academic instruction that is led by a teacher regardless of the quality of instruction (learners are considered to be provided with DI for most of the lesson-time followed by reinforcement activities under teacher's supervision – no instructional procedures explicated); 2. The instructional procedures that were used by effective teachers in the teacher effects research (instructional procedures used by teachers whose students perform better in assessments – process-product tradition); 3. Instructional procedures used by teachers when they taught cognitive strategies to students (simplifying tasks in initial practice; scaffold and guide for student support at initial practice; provide supportive and guiding feedback); 4. Instructional procedures used in the Distar (Direct Instruction Systems in Arithmetic and Reading) programs (Explicit step-by-step strategy; mastery development at each step; specific corrections for student errors; gradual fading of teacher direction towards student independent work; adequate and systematic practice with examples; cumulative review of learned concepts); 5. Instruction where direct instruction is portrayed in negative terms such as settings where the teacher lectures and the students sit passively (DI as the pouring of information from one container, the teacher's head, to another container, the student's head).

In the descriptions of both Adams and Carnine (2004) and Rosenshine (2008), DI is given different meanings according to how the words are used, and characterising details per use. However, in all cases the teacher is placed at the forefront of all the procedures of the teaching process. This implies that though in some cases (in the description) the internal operational

procedures are not explicated, the teacher is predominantly considered as the sole bearer and deliverer of the knowledge to learners to whom the aim is to implant the skills (such as performing successfully the arithmetic procedures) as opposed to a long conceptual knowledge development.

Although Adams and Carnine (2004) qualify teacher-led instruction or explicit teaching as highly structured, they argue that the sole target of DI is to enable learners to attain mastery of fundamental skills. They further attest that the fundamental philosophy of DI is that "if the student has not learned, the teacher has not effectively taught", and that the "students who mislearn information require substantially more time and effort to relearn concepts than they would had they learned them correctly in the first place" (p.370). Besides emphasising the teacher-authoritative nature of DI, the latter contentions resonate with Sfard's (2008) idea of ritual routines performance in which the teacher is the central authority and focuses on the learners' mastery of rote mathematical procedures as opposed to deeper understanding of concepts (see Chapter 3).

Citing the work of Nur (2004), Firmansyah, Gradini, Yustinanningrum, and Lubis (2019) brings the discussion to the five stages in the sequential proceeding of direct instruction-oriented teaching. These are: Preparation - conveying the learning objectives and motivating students; Demonstrations - explaining and demonstrating a specific learning strategy; Guided training - providing opportunities for students' guided training; Feedback - checking students' understanding and providing guiding feedback; Advanced Training - providing independent training and applying different situations (p.3).

The same sequence of stages is highlighted with a different wording (as components) by Adams and Carnine, (2004, p.371 - 372) who draw these from the work of Joyce and Weil (2004). Their naming of these stages include: Orientation – providing students with overview of the lesson, explaining why students need to learn the upcoming material, reviewing material learned or experienced previously (prior knowledge and experience activation) and telling students the demands of the upcoming learning material; Presentation – explicit explaining, illustrating and demonstrating new material; breaking down the lesson into small easy-to-learn steps for mastery of steps, these done through a series of examples to ensure mastery of all steps; Structured practice - involves highest degree of teacher assistance where the class is led through each step in a problem or lesson with the aim to minimise incorrect responses, using

visuals, reinforcing correct responses and correcting errors; Guided practice - involves students working on teacher-explained and demonstrated problems while teacher circulates with the aim of checking for and correcting any students' errors; Independent Practice - follows guided practice on condition that students show higher capacity to correctly execute teacher-demonstrated (previous) problems, hence are encouraged to practise the same procedures independently while in class or at home, while the teacher assesses and provides feedback at a delayed later stage.

In principle, these DI components further describe the teacher-centredness of the DI which basically could limit opportunity for learners' autonomy and independence while most probably promoting learners' passive participation or performance of rote procedures throughout the learning process without deeper understanding of the underlying concept. In the words of Hodgen, Foster, Marks, and Brown (2018), the description and operational detail of DI renders it incomplete because it lays much emphasis on the general teaching techniques used and too little attention on what is taught (the conceptual knowledge).

The discussion herein further identifies DI as a teaching approach comprised of strategies that focus on the development of learners' procedural fluency as opposed to conceptual understanding. Here, procedural fluency is defined as "knowledge of procedures, knowledge of when and how to use them appropriately, and skill in performing them flexibly, accurately, and efficiently" (Phuong, 2020, p.1337); whereas conceptual understanding is defined as an "integrated and functional grasp of mathematical ideas, which enables them [students] to learn new ideas by connecting those ideas to what they already know" (Phuong, 2020, p.1336). These DI strategies therefore involve transmission of information from teacher to learners (Petersen & Gorman, 2014). The teacher provides the introduction, explanations, demonstrations and examples of a procedure for a concept and gives learners a similar (to one in the example) problem to practise the procedure while passively acquiring information from their teacher (Vale & Barbosa, 2020). This therefore describes DI strategies as a direct opposite of the active teaching and learning strategies. It however does not explicitly describe the relation of this approach to LA.

Focusing mostly on DI's teacher-dominant operational processes, its focus on skill and procedural proficiency development and learners' passive participation, and its LA-

compromising processes, the present study used DI as part of the analysis package to describe the nature of the observed classroom as opposed to the active instructional approach.

2.1.2 Active instructional approach – teaching and learning

The term 'active' is commonly (in research) associated with the learners' act of learning (active learning) since it is construed as key to learner-centred instructional approaches. It is however associated with the teaching process through the teaching strategies which facilitate the learners' active involvement throughout their learning process (Konopka, Adaime & Mosele, 2015). The present study therefore uses active instructional approach to denote active learning and strategies which engage learners with it.

Though active instructional approach is often claimed to be a broad term which lacks a direct and common definition, it is used to give a description to instructional approaches which allow learners to take responsibility for their learning process (Michel, Cater & Varela, 2009), which reflects its close and causative relation to LA (see Section 2.1 for discussion on LA).

As Freeman, Eddy, Mcdonough, Smith, Okoroafor, Jordt and Wenderoth (2014) put it, as a way to develop learners' critical thinking on the subject matter and nurture their teamwork, strategies in active instructional approach allow the teacher to fully engage learners, creating opportunities for physical activities and debates, instead of their passive listening and watching the teacher. In appreciation of their academically recognised importance in the learners' development (that is, improving conceptual understanding, retention, problem-solving, and critical thinking skills), active instructional approach strategies are understood to be constructivist, collaborative, interdisciplinary, contextualized, reflective, critical, investigative, motivating, challenging, and humanist (Konopka *et al*., 2015).

With regard to the discussion herein (besides their implicitness on LA in mathematics) on active instructional approach (its description, strategies, and importance) and for the purpose of data analysis in the present study (while in opposition to DI), active instructional approach is considered a teaching approach signified by learner collaboration, dialogic and interactive communication (teacher-learner, learner-learner) (see Section 3.1.2 for discussion on interactions and communicative approach), critical questioning, challenging and problem-solving lesson practices, and non-passive presentations by the teacher.

2.2 Mathematical Discourses and Routines - Dialogical Nature of mathematics Classroom

Recent research aims to explore the type of teaching-learning environment which fosters meaningful mathematical conceptual development (Rosita, Wardono & Kartono, 2018). The absolute impression is that an effective mathematics teaching and learning environment should engage learners in solving and discussing tasks and problems that promote mathematical reasoning (Doruk, 2014) and facilitating classroom discourses to enable shared conceptual understanding through analysis and argumentation (Brahier, Leinwand and Huinker, 2014; Flick & Kuchey, 2015).

According to Bennett (2019), discourses in a mathematics classroom improve learners' mathematical reasoning and conceptual understanding through intentional, focused and shared social interactions to enable learners to reason out, confirm and challenge their mathematical ideas. In this sense a rich meaningful discourse in a mathematics classroom may be defined as "interactive and sustained discourses of a dialogical nature between teachers and students, and among students, aligned to the content of the lesson that addresses specific student learning issues" (Piccolo, Harbaugh, Carter, Capraro & Capraro, 2008; p.378).

As part of a discursive learning process, mathematical discourse involves resolute exchange of views through discussions, verbally, visually or by written arguments. This therefore gives learners an opportunity to share understandings, argue on mathematical ideas and their origins whilst seeing things from diverse perspectives (Kollar, Ufer, Reichersdorfer, Vogel, Fischer & Reiss, 2014; Mueller, Yankelewitz & Maher, 2014). Therefore, to analyse learners' level of understanding of the mathematics concepts, the depth of their cognitive engagement with the concept and their competence, the present study looked into learner-learner discourses and teacher-learner discourses. Besides addressing its third research question, and driven by the description and importance of mathematical discourse detailed herein, the present study raises an argument, in an assumption that more beneficial mathematical discourses occur when learners are autonomous, though this may not be a common and easily visible case in schools, this assumption drives the focus of this study.

The characteristic descriptions of different types of discourses (formal, informal and colloquial) are discussed in Chapter 3 and a distinction from mathematical discourses is

established. This includes the discourse objectification and how it relates to ritual or exploration routines.

2.3 Active Teaching and Learning of Mensuration and Learner Competences

Though active learning is often claimed to have no direct and common definition, it is characterised by a classroom environment that involves teaching-learning strategies which stimulate learner-learner and learner-teacher interactions (Petersen & Gorman, 2014). Such environment must allow learners to engage in mathematics tasks requiring their deeper cognitive engagement where they construct meanings and conceptual understandings and make connections on the subject matter (Bjørkestø, Borge, Goodchild, Nilsen & Tonheim, 2021). Such an environment should also involve strategies which integrate intellectual, social and physical engagement to enable learners' pleasant experiences as they interact with the subject matter (Vale & Barbosa, 2023).

In contrast, direct and traditional strategies involve transmission of information from teacher to learners (Petersen & Gorman, 2014). The teacher provides the introduction and examples of a procedure for a concept and gives learners a similar (to one in the example) problem to practise the procedure while passively acquiring information from their teacher (Vale & Barbosa, 2020). This is therefore a direct opposite of the active learning environment. The present study therefore considers active teaching-learning strategies as those that allow learners collaboration, discussions and manipulations as they work on open mathematics problems, their elaboration and reasoning for their solution strategies and answers, and reflection and evaluation of their learning or understanding of the mathematics concepts at hand. Direct instructional approach – on the other hand – is considered a teaching learning environment where learners remain passive facing the teacher while the teacher introduces concepts through detailed explanations, demonstrating procedures with examples and providing learners tasks similar to the given examples for them to practise the use of procedures to maximise their memorisation of such processes.

In fields such as engineering and architecture, learners need a deep conceptual understanding of objects in 3-D space to build models, and solve problems before building real objects (Agustin & Tindowen, 2019), hence the study of Mensuration assists learners in gaining better understanding of their environment and how it can further shape their lives (Thomas, 2023). This partly describes the significance of the concept of Mensuration, which Otumudia (2017)

classified into two major branches: Plane Mensuration, which involves the study of Rectangle, Square, Circle, Triangle, Parallelogram, Trapezium, Rhombus, Length of arc, and their properties such as Perimeter, Area, Perimeter of a sector, Area of a sector, Length of a chord, Perimeter of segment of a circle, Area of segment of a circle, Regular and Irregular plane shapes; and Solid Mensuration, which involves the study of properties of Cylinder, Surface Area and volume of cylinder, Hollowed cylinder, pipes and rings, and Cone, properties and measurement on cones formed from a sector, Sphere and Hemisphere, Triangular Prism, Cube, Cuboid, Pyramid, Frustum, and Irregular solids.

However, research discloses that many learners show lack of understanding of Mensuration concepts (Agustin & Tindowen, 2019; Nts'asa & Machaba, 2019). This lack of Mensuration skill and understanding is pinned on 'traditional' teacher-centred teaching methods as opposed to concept-based methods. These are approaches in which teachers focus more on fluency in computational procedures and usage of ready-made formulae instead of discursively deriving those procedures and constructing meaning around them. The study therefore raises concerns on the pedagogical capacity of teachers to prepare learners for concept-based problems.

To enable learners' deep understanding of Mensuration, the classroom environment should promote active engagement (Akiha, Brigham, Couch, Lewin, Stains, Stetzer, Vinson & Smith, 2018). When actively engaged, learners actually and physically do mathematics (using concrete materials), engage in argumentation and synthesise new ideas by connecting major concepts. This increases learners' courage, interest and confidence to engage with tricky concepts such as surface-area and volume of concrete objects, hence their increased competence in these concepts (Kudakwashe & Sunzuma, 2016).

In terms of their competence in the Mensuration concepts, Molina and Bansil (2018) posit that learner confidence strongly correlates with their performance in solid Mensuration. Learners who were more confident tended to perform better, while those who lacked confidence had lower performance in this area. It is therefore important that the classroom environment involves instructional strategies which allow and maximise learners' active engagement to boost their confidence and, ultimately, their performance in Mensuration concepts. Similarly, exploratory approach is considered a good support for deeper understanding of concepts of Area and Perimeter since it offers learners opportunity to explore and manipulate these

concepts, and engage in deeper mathematical discourse where they suggest and reason for their answers and conclusions as they work on open problems (Richit, Tomkelski & Richit, 2021).

Learners get exposed to and grapple with valuable mathematical tasks to which they have no preconceived or immediate strategy or procedure to use, hence have to activate their prior knowledge and skills to find the solution, and they do so through collaborative discussions to gain meaning for mathematical procedures and concepts, and develop mathematical capabilities including problem-solving skills, mathematical and logical reasoning and explorative discourse (Ponte, 2005; Canavarro, 2011). These active-learner considered approaches therefore could be said to promote the curricular-proposed learner autonomous environment and boost their confidence and competence in the concepts of Area and Perimeter.

In recent research, there exist a number of teaching and learning practices and approaches (some of which are technology-based), through which learners were found to show positive academic reaction to the learning of Mensuration. Sochima (2022) found that when exposed to a constructivist teaching method (which is said to be activity-based, practically oriented and learner-centred), learners' interest and conceptual understanding in Mensuration improved better than those taught through expository method. Similarly, technology-based instructional approaches, such as Computer Aided Instruction (CAI) (Zakariyya, 2022), and tools such as GeoGebra software (Akwensi, Komla, Amanyi, Bornaa, Abugri & Kombat, 2023) were found to enhance learners' understanding and performance in geometry, including Mensuration, compared to conventional methods of teaching mathematics.

In most cases, studies show statistically low performance in Mensuration as a topic when taught with conventional methods compared to actively engaging methods (for example, Salami & Spangenberg, 2024). In Fuat, Susanto, and Aini,'s (2020) study, when taught with more conventional methods, learners showed misconceptions and errors related to the definitions of Mensuration concepts, formulae, interpretation of related problems, computational errors and incorrect choices of formulae, and units of concepts such as area of triangle. However, the latter approaches have limitations and are implicit on the practical and autonomous nature of the classroom environment learners were exposed to, which is the major focus of the present study.

2.4 Effective mathematics Learning Strategies and Learner Competences

Viewed from the perspective of CAP and the Grade 8 mathematics syllabus (MoET, 2009; 2017), active instructional approach to mathematics learning and teaching is construed as an interactive situation in which learners show much responsibility for their learning by identifying, formulating and solving mathematical problems by themselves. Learners also continuously evaluate their progress in their knowledge development. The main emphasis is on the learners' overall behaviour and activities. All these activities are envisioned to foster values and positive attitudes such as learners' collaboration and confidence in learning independently. The teacher is expected to provide scaffolding and descriptive feedback to assist learners realise areas of success and those that need improvement (MoET, 2009).

However, research on learner participation, and general mathematics learning behaviour, reveals that mathematics performance is still not satisfactory even in recent years (Mji & Makgato, 2006; Gitaari, Nyaga & Reche, 2013; Sa'ad, Adamu & Sadiq, 2014; Jameel & Ali, 2016; Yakubu & Bolaji, 2019; Chand, Chaudhary, Prasad & Chand, 2021), particularly in Mensuration concepts (Ekwueme, Ekon & Ezenwa-Nebife, 2015; Agustin & Tindowen, 2019; Thomas, 2023). This implies that research on the curricula-proposed strategies still needs to focus on how well they are utilised to influence good performance in Mensuration.

There exist several teaching and learning strategies in research which are tagged learner-centred in nature and vital for learners' apprehension and performance of mathematical concepts including Mensuration concepts. These include self-instruction and peer-tutoring in which the majority of the learner-success-bearing elements of the lesson (such as goal setting; keeping on task; remembering appropriate procedures to follow; proof checking answers) are the responsibility of the learner (Steedly, Dragoo, Arafeh, & Luke, 2008). However, Steedly *et al.* (2008) argue that in this kind of learning environment, the low performing and less confident learners get somehow disadvantaged.

In a study to test the impact of a co-operative learning strategy on the improvement of learner performance in Mensuration concepts, Yakubu and Bolaji (2019) found that learner performance improved greatly when using this strategy. According to Yakubu and Bolaji (2019), to use co-operative learning strategies, learners of different ability levels sit in small groups in which they use a variety of learning activities to improve their understanding and competence. Learners play such that each is a member of two groups; home group and expert

group. Each learner in the expert group (the 'smart' ones) is given a set of rules to teach other learners in the home group. Though this method is reported to improve learners' performance (Gambari, Shittu & Taiwo, 2013), it has a potential to disadvantage learners who are less active in the group, who have difficulties understanding quickly, are less confident and therefore are less often selected to be in the expert group.

One of the learning strategies considered to foster learner participation is a problem-based learning, which is reported to improve learners' critical thinking hence having a positive influence on learner performance in mathematics (Mulyanto, Gunarhadi, & Indriayu, 2018; Talib & Kailani, 2014). The focus is on problem-solving strategies in which learners construct knowledge, develop inquiry and appraise thinking skills. In employing problem-based learning strategy, learners are given the chance to generate a temporary answer to a problem and then work towards a more 'active' solution process (a gesture that requires logical intelligence, tenacity and active solution strategy). Mulyanto *et al.* (2018) further insist that problem-based learning strategy actuates active learning, creates opportunities for learner development of mathematical knowledge, skills and attitudes in a collaborative learning situation.

In a similar move, to improve learner achievement in Mensuration in an Asian region, Agustin and Tindowen (2019) found outcome-based education (OBE) to be most adequate for elevation of learners' scores, enhancement of their learning and stimulation of their interest in Mensuration. In OBE, learners are provided with written text which enlists a topic of discussion; learning outcomes; concept development strategies (which are learner-based); guided practice (provided by teacher); and self-test and evaluation items. However, as opposed to the above discussed strategies, OBE is implied to involve much of the teacher's intervention and evaluation to assess if the intended learning has occurred. Nevertheless, OBE was reported impossible to implement in South African township schools due to some impediments such as inadequate teacher capacitation, overcrowding, and learners' poor background (Motseke, 2005).

Based on these discussions, the current study argues that if learner-based strategies and learning environments were to be implemented in Lesotho secondary level schools, some of these impediments have to be considered and research such as the one in this study could be an eye-opener and informative towards such implementation. This is to say, the findings of the present

study provide the practical base which the MoET and other stakeholders may consider in order to avoid failure in implementation of the LAE-oriented curriculum.

2.5 Classroom Interactions in mathematics Education

The types of interactions that occur in a mathematics classroom are crucial as they contribute to shaping learners' engagement and influencing their learning. There are different types of interactions that occur between learners and teachers in the classroom. Abulhul (2021) classified these as one-way, two-way, and multi-way interactions. One-way interaction occurs when only one person speaks, usually the teacher. In an interactive classroom setting, one-way interaction occurs when the teacher gives learners instructions about classroom activities or explains a new concept. Two-way interaction occurs through communication between teachers and learners. This interaction takes place when the teacher invites learners to voice their ideas, answer questions, and the teacher also reacts to learners' answers. Multi-way interactions occur during discussion activities, where learners share ideas while working on problems, and the teacher also participates in the communication by guiding learners and attending to their questions. Scott *et al*. (2011) referred to these types of interactions as elements of the communicative approach: non-interactive/authoritative, interactive/authoritative, and interactive/dialogic approaches, respectively (see Section 3).

The interactions between teachers and learners are beneficial for both parties as they provide a space for communication about the subject matter. In this way, interactions become a pedagogical tool that enables teachers to create a conducive space for learning (Schwarz, Dreyfus & HershKowitz, 2011). The value of teacher-learner interactions in fostering conceptualisation and engagement in mathematics classrooms has been emphasised by Pinta, Hamre, and Allen (2012) who contend that high learner involvement is correlated with positive teacher-learner interactions. Their findings further emphasise the importance of promoting supportive interactions between teachers and learners in mathematics classrooms. Learner-focused interactions foster the development of mathematical reasoning and independent thinking skills (Song, Zhang & Liu 2023; Tainio & Laine, 2015). Learners who have acquired these skills are more confident and can use logic, critical thinking, and make connections to solve mathematical problems. A study conducted by Ayuwanti, Marsigir, and Siswoyo (2021) suggests that mathematics teachers who demonstrate a deeper knowledge of the subject matter have the ability to create engaging lessons and lead interactive interactions with learners, as well as establish a positive learning climate. However, learners' levels of engagement also

influence their perceptions of the value of mathematics. This suggests that interactive teacher-learner interactions play a critical role in learners' academic achievement. Conversely, Ayuwanti *et al*. (2021) propose that negative teacher-learner interactions can have a detrimental effect on learners' learning outcomes.

Peer interactions have also been recognised as a significant factor in promoting learners' ability to make sense of mathematics (Lo & Ruef, 2020). In their research, Lo and Ruef found that learners can effectively engage in mathematical sense-making when they have the opportunity to participate in classroom discussions as active contributors. Their study revealed that in classrooms where sense-making is emphasised, learners are not only encouraged to present and acknowledge each other's ideas but also engage in revising arguments and taking risks by sharing their own thoughts.

In summary, the existing literature on interactions within mathematics classrooms highlights the complex dynamics of teacher-learner interactions, peer interactions, and learner engagement. The deliberations herein support the idea of teacher-learner interactions which are interactive and allow learners to raise their opinions and argumentatively engage with the subject matter; whether as a teacher-led discussion or problem-solving discussion among learners. This therefore pursues the development and nurturing of learners' ability to engage independently in their learning process. Though I have not come across a research study which directly relates these classroom interactions to the concept of learner-autonomy, the discussion in this part of the literature review supports the promotion of the learner-autonomous environment and qualifies it as involving interactive and learner-focused interactions between the teacher and learners and among learners themselves.

2.6 Pedagogy - Role of the Teacher

Some recent research on mathematics teaching and learning insist on learner-centred strategies (for example, Confrey, Gianopulos, McGowan, Shah & Belcher, 2017). However, in a real classroom situation, the learning process is guided and monitored by the teacher (Sachdeva, 2019). In this sense, the teacher is considered a mediator between the learner and the mathematics concept to learn. The teacher plays a vital role of facilitating active engagement and spiking classroom discourses over mathematics concepts.

For effective discourses, teachers need to pose questions which reveal learners' needs about the lesson (Reeve & Tseng, 2011). They need to respond accordingly to learner-generated questions; attend learners' difficulties to show emotional support; nurture competence and use non-controlling communication (Stefanou, Perncevich, DiCintio & Turner, 2004). This implies that it is important that the teacher possess adequate pedagogical knowledge to continuously diagnose learners' difficulties and promote their active participation. However, in a recent study, Qhobela and Moru (2020) revealed that Lesotho secondary school teachers held onto teacher-centred instructional strategies and did not involve learners in some engaging classroom talk through posing critical questions. This therefore poses a further need for a research study focused specifically on the teachers' mathematics pedagogical practices in the implementation of the reform-oriented curriculum.

Research reveals that even if learners may seem capable of conducting mathematics learning independently, it does not remain that way permanently, thus the teacher needs to always provide scaffolding through discourse (Bakker, Smit & Wegerif, 2015). When teachers ask open questions regularly, learners' willingness to participate in discourse gradually increases and their responses become longer while they try to make sense of the subject matter (Snell & Lefstein, 2011; Šeďová, Švaříček, Sedláček, & Šalamounová, 2014).

This contention makes more emphasis on the teacher-learner communication and its advantages on the learners, but does not neglect the fact that learners must be actively engaged in their learning, and must influence the teaching-leaning environment by executing the activities cooperatively (Šeďová *et al.*, 2014; Thuneberg, Salmia & Bognerb, 2018). This therefore demands the teacher's commitment to ensure that the required learning occurs through discourse even if the classroom environment is autonomy-supporting. This study will seek to determine if teachers understand this commitment throughout the teaching-learning process.

2.7 Learner-Autonomy in mathematics Teaching and Learning

While focusing on the restructuring of educational goals, it is important that the new education system is focused on the learner outcomes. This implies that the attention of the teaching-learning process is on the quality of learning (Dundon, 2012). This idea could benefit from a learner-centred environment such as LAE. According to previous research, to be autonomous,

learners need to understand the purpose of their learning programme, explicitly accept learning responsibility, contribute in goal setting, execute learning activities, and regularly review and evaluate learning (Little, 2003); a contention which describes LA as the learners' full capacity to take control of their own learning (Benson, 2013). In the teaching and learning of mathematics, LA is defined as learners' capability to solitarily think about mathematical ideas and solve mathematical problems without anyone showing them a method to follow (Warfield *et al.*, 2005).

The descriptions of LA herein, however, seem to identify it as a difficult construct to implement and maintain in the real classroom, and echo a traditional viewpoint. Recent research has led to a reconsideration of mathematics autonomy as not just the ability to solve problems independently, but also the capacity to recognise and evaluate different problem-solving strategies and to choose the most appropriate approach for a given situation (Wang *et al*., 2015). Another way to look at LA in the mathematics classroom is to focus on building a collaborative learning community which may involve creating opportunities for learners to harmoniously work together to solve problems, share their thoughts, and physically and emotionally support each other's learning (Smith, 2015). Borg and Alshumaimeri's (2017) echoed this in their findings in which teachers described LA in a mathematics classroom as relative to learners' independence and control in their learning, and as their capacity and self-motivation to execute mathematics tasks either individually or collaboratively with minimal help from the teacher.

Since in a real classroom situation teaching and learning cannot be divorced from each other, the types of teaching approaches may be responsible for the attainment of this level of LA. For learners to attain this level of mathematics classroom autonomy and its educational benefits, the teacher has to create a classroom environment which allows the learners to get involved in exploring mathematical ideas, make conjunctures about those ideas, and provide mathematical justifications for their conclusions and solutions (Warfield *et al.*, 2005). This may include approaches and practices such as availing tasks which have imagery, and slightly highlighting key issues in the subject matter and allowing learners to deliberate on them while utilising concrete materials (Akyuz & Stephan, 2020). Akyuz & Stephan emphasise that it is important that teachers establish social and socio-mathematical norms in a classroom to give learners the opportunity to explain and substantiate their mathematical ideas. This signifies the importance of instructional approaches, and communicative approach to the promotion of LA in a mathematics classroom.

The learners' ability to learn autonomously directly impacts their effective learning (Zhifeng, 2017). Besides the effectiveness of the learning process, LA has a positive influence on learners' overall academic performance. As Sun (2023) puts it, "the more the learners have a sense of autonomy in their learning, the higher and better academic performance or learning outcomes they get" (p.208). When learners are autonomous in a mathematics classroom, they get an opportunity to build confidence to argue reasonably, discuss and design better learning opportunities in mathematics with the teacher and other learners. By so doing, learners may be able to engage in decisions concerning their mathematics teaching-learning process with their teachers (Sachdeva, 2019). This is one of the points of emphasis in the present study since this type of learning gives the learner the ability to exercise their partial authority and develop their classroom discourses which foster and reflect their competency on conceptual understanding.

As learners progressively engage in active mathematics learning, their classroom autonomy improves, hence they acquire skills necessary to overcome mathematics learning obstacles, such as mathematics anxiety (Dundon, 2012). Even so, it is important to understand the difference between LA and learner independence. LA is a teacher-learner collaboration where each partake in designing, planning, executing and analysing different strategies to identify those that are beneficial for learners' mathematics learning (Sachdeva, 2019). This collaboration is considered, in this study, a promoter of a harmonious environment proposed by the CAP. The literature, however, is not explicit on the types of classroom interactions (especially teacher-learner) and instructional approaches which contribute effectively on the learner autonomous classroom environment. The present study hence explored the approaches and teacher-learner interactions to which learners were exposed, as a way of describing the level of opportunities provided by their teachers for their LA.

2.8 Conclusion

As discussed in different sections throughout this chapter, LA is understood, in the present study, as a beneficial construct towards learners' outcome, especially their competence in terms of conceptual understanding and mathematization in general. Even so, the literature shows diversity in the instructional approaches available for use in any mathematics classroom. Among these approaches, active instructional approach, on the one hand, is defined and considered as one way to create ample opportunities for learners to progressively be autonomous throughout their learning processes.

Direct instructional approach, on the other hand, is seen as an impediment to the learners' autonomous learning process, though it is the first and easier approach for novice and less committed teachers. Though I have not come across any recent research reporting on the pedagogical interrelation of the active and direct instructional approaches to the learners' autonomous learning, the study deployed its analytical inclinations to substantiate the existence of such links as a contribution to the growing body of knowledge in mathematics educational research.

For further and triangulated substantiation on the importance of creating a learner autonomous classroom environment in the teaching of mathematics, the study reviewed and discussed the importance of promoting formal mathematical discourses and constant use of exploration routines. This included the use of objectified mathematical discourses as a way of creating chances for learners to maximise the use of explorative routines. In this discussion, exploration routines were argued to allow learners to progressively engage autonomously with mathematics concepts while showing competence in terms of enculturation into mathematical ways of communicating.

On the other hand, ritual routines, coupled with disobjectified colloquial discourses, are regarded as a hindrance to the curricular-proposed learner autonomous environment. This contention was further iterated by Warfield *et al*. (2005) when they postulated that learners attain the acceptable level of mathematics classroom autonomy and its educational benefits, if the teacher is able to create a classroom environment which allows the learners to get involved in exploring mathematical ideas, make conjectures about those ideas, and provide mathematical justifications for their conclusions and solutions.

In addition to the types of instructional approaches, discourses and routines appropriate in a mathematics classroom for promotion of LA and conceptual understanding, the chapter discussed the importance and relation of teacher-learner interactions in a mathematics classroom. In all these discussions, the study argues the importance of interactions which allow learners to contribute dialogically in their learning hence allowing them to progressively develop competence in critically and independently thinking and communicating about mathematics ideas.

The discussed literature, and the subsequent research methodology executed, are laid down herein as a way of bridging the literature gap in the definition of LA in a mathematics classroom, the instructional practices (instructional approaches, interactions, routines and discourses), and the learning practices and competences, all contributed to the structure of learner-autonomous environment. The study therefore aimed to formulate the description of a learner-autonomous environment, in a mathematics classroom, as a situation which consists of active instructional approach, minimal direct instructional approach, use of formal mathematical discourses and exploration routines both on the side of the teacher and the learners, and interactions which allow learners' contribution in their learning process.

Chapter 3: The Conceptual and Theoretical Frameworks

3.0 Introduction

Having discussed the related literature, this chapter discusses the conceptual and theoretical frameworks guiding the study. The frameworks were intended to help in describing and interpreting the nature of the instructional environment learners were exposed to and how teachers seemed to understand their roles as learner autonomy (LA) promoters and active learning facilitators. The concepts from the incorporated theories were selected and integrated with the concepts of Active and Direct instructional approaches (discussed in Section 2.1), and some curricular constructs to form an ideal conceptual framework (LAMLE) which could be deployed in classroom analysis of LA-promoting opportunities for mathematics teaching and learning (see Figure 3).

The conceptual framework was developed by outlining the concepts which collaboratively describe the expected practices in an *Autonomous Mathematics Learner* (AML) (or otherwise), as dictated by the CAP and the syllabus (MoET, 2009; 2017). These concepts were theoretically reinforced by a detailed discussion of two related theoretical perspectives about teaching and learning processes, the *instructional discourses* and routines, and *classroom interactions*. The concepts from the two theoretical perspectives were selected and systematically linked by highlighting aspects from each: *Approaches to Pedagogical link-making* and *Communicative approach* (Mortimer and Scott, 2003; Scott *et al*, 2011), and Sfard's (2008) *commognition's routines* (**E**xplorations and **R**itual routines) and *discourses* (**F**ormal (mathematical) and **C**olloquial discourses; and **O**bjectified vs **D**isobjectified discourses).

Each of the two main curricular constructs [and the two embedded constructs] (elaborated in Chapter 1, Table 1) were elaborated and incorporated in this study such that addressing each sub-research question would imply conformation to each of the corresponding constructs. The curricular constructs (Learner Core Competencies; Learner Autonomy; Pedagogy; and Learner Mensuration Skills) function as part of the framework from which the research questions were partially constructed, also in connection to the concepts from the two theoretical perspectives. The two theories were incorporated to provide a theoretical framing to these constructs so that they collectively help in explaining how *active participation* may be facilitated and how

learner-autonomous environments may be promoted, especially during the teaching/learning of Mensuration concepts (*Perimeter* and *Area*). The following section discusses how the two theoretical perspectives supplement each other to describe an effective teaching or learning process and determine the degree of learner autonomy throughout each lesson.

3.1 The Theoretical Frameworks

This study explores the nature of learning environments learners were exposed to in the light of or in contrast to LAE. This includes: the types of *learner-learner discourses* and *teacher-learner discourses,* and *communicative interactions*; how these contribute in *learners' conceptual development of Mensuration*; and how teachers facilitate *active learning* and promote *learner-autonomous environments*. This was viewed through a participationist view of mathematics teaching and learning as a discursive and communicative activity driven by vital interactions between teacher and learners and/or learners themselves. Therefore, vital to this study were the two theoretical perspectives: Commognition (Sfard, 2008), Pedagogical link-making and Communicative approach (Mortimer and Scott, 2003; Scott *et al*, 2011).

3.1.1 The Commognition theory

Commognition theory is anchored in the assumption that thinking is a form of communication (intra personal) and that learning mathematics is equivalent to modifying and extending one's discourses (Sfard, 2007). This theory combines *communication* with *cognition*. As such "a discourse analysis based on Commognition can explain the relationship between interpersonal communication and the cognitive process and how teachers and students move towards a meaningful discourse through participation" (Kim, Choi, & Lim, 2017, p.841). It is therefore through observation of teachers' and learners' actions and talk that interactions can be analysed and their effectiveness determined (Mudaly & Mpofu, 2019). The present study aimed at exploring the mathematical communicative nature of the teaching-learning environment during the teaching of Mensuration concepts hence the Commognition theory provided the analytical platform for such investigation.

According to Sfard (2008), the 'autopoietic' (*"system that contains objects of talk along with the talk itself and grows from inside as new objects are added one after another"*) nature of mathematics, labels it as a discourse, (a notion different from being a language since discourse "denotes human activity while language is a symbolic system" (p.129). Therefore, looking into the types and intensity of the overall discourses during the teaching of Mensuration concepts

was a way to study the effectiveness of the teaching-learning interactions and the power relations of these two interlocutors (Sfard, 2008) (a notion closest to the idea of learner autonomy).

In the Commognitive perspective, different patterns of communication are labelled as discourses of unique types. In this study, I present distinguishing characteristics of three common types of discourse, formal, informal and colloquial. Peoples' discourses are formal if they involve strictly mathematical symbols, notations and algorithms, which allow them to communicate mathematically (Sfard, 2008), while informal discourses are conversations which may involve some mathematics jargon with lack of rigour that is possessed by formal discourses (Essack, 2015). The discourses among people can be said to be colloquial if they mostly involve conversation about everyday non-mathematical concrete objects which happen to intrude during a discussion on a mathematical concept (Sfard, 2008). Special attention is placed on the latter type of discourse since it is highly likely to occur in a real mathematics classroom, especially where no special consideration of active and effective interaction is prioritised.

As Sfard (2008) puts it, as opposed to mathematical discourse, colloquial discourse involves "material things and objects of communication which exist independently of the discourse and can be pointed to and scanned with one's eyes" (p.135). Objects of mathematical discourse are described here to feature as something that can be represented visually yet not really shown. As a result, it is insisted that mathematical discourse is highly likely to be affected by differences in the use of words by people involved in the communication. This said, it is worth detailing the commognitive structure of a mathematical discourse. According to Sfard (2008), there are four properties of a talk which could be considered to characterise it as mathematical discourse: *word use*, *visual mediators*, *narratives* and *routines (p.133 - 135)*:

> *Word use*: Discourses are characterised by the key words used in them. In particular, mathematical talk is distinguished by the use of words that indicate quantities and shapes, and though these could still be found in other forms of discourse (for example, colloquial discourse), school mathematics and academics use them in a specialised and "more disciplined" manner (that is, the manner which characterises the way they see and talk about things in the world). In Mensuration teaching and learning, these words may include aspects such as Perimeter, Area, total length, surface covered.

Visual mediators: These are visible objects that people in communication operate as part of their communication. Unlike colloquial discourses, which use images of material things existing independently of the discourse, mathematical discourses involve symbolic artefacts, created specifically for this particular form of communication (p.134). From the school learning of concepts of Area or Perimeter, these artefacts could be represented by formulae, equations and shapes (their dimensions) operated during the communication about these concepts. As articulated by Sfard, the learners' experience in operating these artefacts creates permanent structures in memory for the concepts in discussion hence makes it better to remember the concept as opposed to simple rote verbal description of these concepts.

Narrative: This is any sequence of utterances framed as a description of objects, of relations between objects, or of processes with or by objects, that is subject to endorsement or rejection with the help of discourse-specific substantiation procedures. Terms and criteria of endorsement may vary considerably from discourse to discourse, and more often than not, the issues of power relations between interlocutors may in fact play a considerable role (p.134). The latter idea of power relations in narrative endorsement may play a vital role in analysing the degree of autonomy provided by the teacher and the collaborative nature of the learners' group work. As Sfard puts it, in mathematical discourse, the endorsed narratives are conclusive statements such as theories, definitions, proofs and theorems. In classroom mathematics teaching-learning of Mensuration concepts, these could be experienced in definitions of concepts, Perimeter and Area, descriptive formulae and final solutions of related problems.

Routines: These are repetitive patterns characteristic of the given discourse. Specifically, mathematical regularities can be noticed whether one is watching the use of mathematical words and mediators or following the process of creating and substantiating narratives about numbers or geometrical shapes (p.134-135). Sfard introduced and distinguished between three types of routines: *deeds, rituals* and *explorations*. The present study used the latter two types of routines to determine the degree of learner autonomy. That is to say, due to the definition of a ritual routine, a more ritual-dominated classroom would hypothetically limit opportunities for learners to be autonomous in their mathematics learning.

3.1.1.1 Distinction and Inter-operation of Rituals and Explorations

As part of the analytical tool, the study looked into the ritual and explorative nature of the teaching-learning routines during the teaching process and problem-solving sessions. The two Commognitive constructs feature as part of the analytical tool since they have features that relate closely to the concept of learner autonomy, which is the main concept that drives the focus of the present study. By definition, *Rituals* are "sequences of discursive actions whose primary goal (closing conditions) is neither the production of an endorsed narrative nor a change in objects, but creating and sustaining a bond with other people" (Sfard, 2008, p.241).

The construction and sustainability of this social bond is achieved by acting with others in harmony, hence doing exactly what these other performers do, to please them and thus bound by these other performers' rules. As dictated here by Sfard (2008), the performance of rituals depends on the availability of mediation and prompt by someone, hence they are extremely restricting. An example could be teacher's dominant prompt sequence to choose the right formula or procedure or the next step in a computational procedure, the action which could limit learners' diversity and promote dependence on teacher's prompt. The latter is further attested by Lavie, Steiner and Sfard's (2019) notion that unlike in the case of deeds or explorations, where the goal is to make a change in objects or produce an endorsed narrative respectively, rituals are performed with a focus on the process or sequence of steps followed to perform such routine while guided by an authority. As they put it,

> …we perform rituals when we feel expected by others to do so, and in particular, when the expectation comes from those whom we see as in any way superior to ourselves. Thus, one can say that rituals are routines performed for the sake of social rewards or in an attempt to avoid a punishment (Lavie *et al.*, 2019, p.166).

Since there are no narratives requiring construction and substantiation (only focussing on how something is done), for this kind of routine to be performed, the figure in authority needs to state all the steps to be followed and performers thus follow strictly these steps to reproduce the routine (Mahlaba & Mudaly, 2022), thus following didactic methods of knowledge development. The authority's probe into *somewhat substantiation* would therefore predominantly use '*how*' as a way to lead learners to narrate a story about the way the task was performed to arrive at the final result, and, typically, if such routine goes wrong one has to repeat it in order to correct (Sfard, 2008).

Explorations, on the other hand, are defined as routines which are performed with the sole aim of producing and substantiating endorsable narratives, liable to acceptance or rejection in accordance with well-defined rules of a specific mathematical discourse (Sfard, 2008). Unlike in the case of rituals, where no different routine performers are expected to follow different routes to arrive at the same conclusion, different designated performers of explorations can follow different paths, however with the expectation that they arrive at the same conclusion, failing which, one could be accused of failure to adhere to the rules of mathematical endorsement (Sfard, 2008).

Sfard divides the explorative nature of mathematical routines into three types: *construction* – a discursive production of endorsable narratives on a specific mathematical concept; *substantiation* – the logical reasoning which helps in deciding whether (or not) to endorse the constructed narratives; and *recall* – a process performed with the aim of retrieving and appropriately use (in a new situation) a narrative that was endorsed in the past. The first and the second of these routine types seem practically difficult in a mathematical classroom situation hence a potential reason for teacher-dominated approaches or authoritative communicative approach dominated by teacher prompts. The last type could easily be expected and observed from the classroom situation since most of these narratives are accessible from textbooks, or the teacher's notes provided in previous lessons.

Further, as opposed to process-oriented rituals, explorations are outcome-oriented (Lavie *et al.*, 2019), hence the exploration performer's main focus is on the final result while allowing different performers' diversity on the process followed to get there. Rituals and explorations are also distinguished by the degree of objectification of the discourses they are a critical part of. To be specific, explorations are considered to involve characteristically objectified (*structured* and *impersonal*) discourses, while rituals involve disobjectified (*processual* and *personalised*) discourses (Sfard, 2008; Heyd-Metzuyanim & Graven, 2016). (Further differences between rituals and explorations are summarised in Table 2).

Table 2. Comparing Rituals and Explorations *[Source: Sfard, (2008) – Thinking as Communication]*

	Ritual	**Exploration**
Closing condition/Goal	Relationships with others (improving one's positioning with respect to others)	Description of the world (production of endorsed narrative about the world)

By whom the routine is performed **For whom the routine is performed**	With (scaffolded by) others Others (authoritative discourse)	No need for scaffolding – can be performed individually Others and oneself (internally persuasive discourse)
Applicability (changing the when, keeping the how constant)	Restricted – the procedure is highly Situated	Broad – the procedure is applicable in a wide range of situations
Flexibility (changing the how, keeping the when constant) **Correctibility**	Almost no degrees of freedom in the course of action Cannot be locally corrected – has to be reiterated in its entirety	The procedure is a whole class of equivalence of different courses of action Parts can be locally replaced with an equivalent subroutine
Acceptability condition	The activity has to be shown to adhere strictly to the rules defining the routine procedure – the acceptance depends on other people	The narrative produced through the performance must be substantiable in such a way that the acceptance is independent of other people
Words' and mediators' use	Phrase-driven use of keywords – as descriptors of extradiscursive mediators	Objectified use of keywords – as signifying objects in their own right

The study therefore observes the degree of objectification of the classroom discourses to determine the ritual or explorative nature of the observed routines. In accordance with how the teachers appear to be using (or not using) the mentioned concepts of Mathematical discourse, the study will provide inferences on the role they play by availing (or not) dialogical classroom environment. The idea of objectification is further discussed in the next sub-section. Though the two commognitive constructs of rituals and explorations do exist and are defined as separate and distinct from each other (as discussed above), there exists, in recent research, a persuasive argument towards their coexistence and inseparability.

To begin with, Sfard (2008) highlighted this as a ladder-trajectory in that "ritual is often a natural, mostly inevitable, stage in routine development" (p.245), and that the child will first master the ritual long before his/her routines are fully fledged explorations. For the same purpose of advancing this argument, Heyd-Metzuyanim and Graven (2019) highlighted a number of studies, conducted at different regions of the globe with varying participants' ages and educational levels. These studies present more diversified views on the rituals including the importance of considering them as a framework to study the culture of the classroom proceedings (Heyd-Metzuyanim and Graven, 2019).

Another important issue raised by these studies is the inseparable coexistence of rituals and explorations in a real classroom situation. For instance, Heyd-Metzuyanim and Graven (2019)

highlight the argument raised by Nachlieli and Tabach (2018) that these two constructs 'always co-exist in a lesson and are even nested within each other'. In that discussion, using operational and lesson-teaching friendly terms, "ritual-enabling" and "exploration-requiring" opportunities, Nachlieli and Tabach (2018), backed by Heyd-Metzuyanim *et al.* (2018), admitted to the slow and gradual nature of ritual-to-exploration transitions, hence insisted that as a way to enable smooth and safe transition of learners from ritual to explorative mathematical discourses, teachers need to gradually enable these opportunities as part of the teaching process for any mathematical concept.

While the latter discussion exists and the two commognitive constructs, ritual and explorations, are regarded inseparable, the present study used the dichotomous nature of these constructs, as discussed earlier in this chapter, as a way to analyse the degree of learner autonomy throughout each observed lesson during the teaching process and learners' discussion groups.

3.1.1.2 Discourse Objectification and mathematics Classroom Routines

In Commognition, one of the prominent properties of mathematical discourse is objectification, "the process in which a noun begins to be used as if it signified an extradiscursive, self-sustained entity (object), independent of human agency", thus, to say objectified discourse means its "keywords are used as if they signified extradiscursive entities, existing independently of this discourse, though, in fact, these words signify discursive objects" (Sfard, 2008; p.300).

Sfard describes objectification in terms of its "two tightly related, but not inseparable" discursive constituent processes, "reification and alienation" (p.44). Reification is defined as a process of substituting talk about actions and processes with talk about objects and states (Sfard, 2008). As an example, in working on a mathematical problem requiring calculation of Perimeter, a reified talk would abandon the process of adding all sides of the polygon and focus on the end product which is the sum. Sfard also defines alienation as a process of presenting reified statements in an impersonal way, "as if they were occurring of themselves, without the participation of human beings". In the previous example, the alienated statement on the definition of Perimeter would move from '*we add all sides of polygon to get Perimeter, or addition of all sides of polygon is Perimeter*' to '*sum of all sides of polygon is Perimeter*'. This way mathematical objects such as numbers exist as entities which existed even before human beings could work on them to produce other objects, products. As Sfard puts it,

> Once reified and put into impersonal sentences, the numbers appear as to have a "life of their own." They return to their human creators disguised as exclusive masters of their own fate, whereas the participant in arithmetic discourse begins experiencing them as "happening to people" rather than caused by them, and as pre-existing discourse rather than as its product (p.50).

To help clarify the terms reification and alienation, Sfard (2008) introduced the idea of words being *structural, processual, personal, or impersonal* nature of a discourse. Here *structural* denotes an utterance that can be understood as describing the structure of a composite number, versus a *processual* utterance, which asserts the calculation as somebody's action or performance, which also goes with *personalisation*. It is therefore understood that the structural nature of word use in objectification, as opposed to being processual, resulted from the reification process, while the impersonalisation resulted from the process of alienation (Sfard, 2008). In simpler words, an objectified mathematical discourse is characterised by its structural and impersonalised nature, while processual and personalised talk is regarded as constituting a disobjectified discourse.

According to Mahlaba and Mudaly (2022), objectification of discourse elucidates colloquial discourses into more specific mathematical discourse with appropriate word usage, performance of routines, construction and substantiation of narratives, and use of visual mediators. Put in simple words, due to the structural and impersonalised nature of objectified discourses as opposed to processual and personalised disobjectified discourse, the degree of objectification can therefore determine and distinguish between colloquial and mathematical discourses. The same could be said with objectification and its implication on ritual and exploration routine performance.

The degree of objectification of the learner's or teacher's mathematical discourse could, in a way, influence the ritual versus explorative nature of their routines. Better stated by Sfard (2008):

> As the rituals gradually turn into explorations, they combine into a tightly interwoven network of partially equivalent discursive routines. In this way, what began as a bunch of unrelated procedures turns into a well-consolidated, objectified full-fledged mathematical discourse. (p.263).

Lavie *et al.* (2019) touched on this idea when they claimed that objectification of the learner's discourse indicates their further progress of de-ritualization. The same endorsement was

provided by Sfard (2008), in an example, when highlighting the fact that as long as the learners' objectification stayed incomplete, (for example, whether structured yet personalised or impersonalised yet mostly processual) their routines while working with numbers remain as rituals. In the same vein, Sfard insisted that if there's completely no objectification in learners' discourse, any new routine they perform will often sound like rituals rather than explorations (p.249). The present study therefore looked into the degree of objectification of teacher-learner discourses and learner-learner discourses to determine their ritual versus exploration status and colloquial versus mathematical discourse status.

While the Commognition theory provides a way to analyse the classroom discourses to provide inferences on their types and the types of instructional routines that exist, the researcher found it important to closely look into the types of interactions that occur throughout each lesson. That is to say, in addition to discourse analysis, since the classroom environments were expected (or not) to allow learner autonomy and allow active participation, the study explored overall classroom interactions in terms of who makes the pedagogical links and the types of communicative approaches used. The latter contention is further contested through a thorough discussion of the theoretical Concept of Pedagogical link-making and Communicative approach by Scott *et al*. (2011) and from Mortimer and Scott (2003).

3.1.2 Pedagogical Link-Making and Communicative Approach

While sourcing their conceptualisations of teaching and learning scientific conceptual knowledge from the theoretical perspectives of constructivism (linking existing knowledge and new ideas) and Vygotsky's socio-cultural theory (knowledge transition from learners' social plane to personal planes through internalisation), Scott, Mortimer and Ametller (2011) introduced the pedagogical link-making framework, as their way to make possible the analysis of effectiveness of teaching-learning interactions in Science classrooms and any other subject. The framework focuses on the ways in which teachers and learners make connections between different forms of knowledge while trying to support learners' deeper conceptual understanding; make connections between teaching and learning events which happen at different times; and how the teacher makes links to encourage a positive emotional response from learners to the ongoing teaching and learning (p.5). These focal points are therefore what Scott *et al*. (2011) call 'The three forms of pedagogical link-making', namely, link-making to support knowledge building, promote continuity, and encourage emotional engagement.

As much as all three forms of link-making are equally important to study the effectiveness of the teaching-learning interactions, the present study considered only two of these forms for the purpose of data analysis, due to the perceived insignificant contribution of the third in the conclusion for the focal concept of the study; learner-autonomy. These are: link-making to support knowledge building; and link-making to promote continuity. The third form of link-making (to encourage emotional engagement) was excluded since it is perceived herein not to provide significant contribution towards the study's conclusion on LA and there were no intentions to look at emotional engagement.

3.1.2.1 Link-Making to Support Knowledge Building

As indicated by Scott *et al*. (2011), this form of link-making is characterised by six approaches which all address the making link between different kinds of knowledge.

Approach 1: making links between every day and scientific ways of explaining

Drawing from several authors in the psychology of learning, Scott *et al*. (2011) articulate that learning science is equivalent to understanding and gaining ability of using the social language of school science. This therefore includes mathematics learning since it often involves operating and talking of objects in the real everyday world together with the strict academic conceptualisation of such objects. This approach is housed in the belief that science learning occurs at times, during everyday ways of talking and thinking about phenomena. The everyday way of conceptualisation may emerge from the learners' experiences on their daily life activities or from their prior lessons.

Approach 1 therefore involves making connections/links between everyday/spontaneous ways of explaining and the scientific ways of explaining, which in some instances overlap while in other instances the two ways of explaining may be totally different. As Scott *et al*. (2011) put it, in those instances where overlaps exist, learning includes making links to integrate the two ways of explaining, while in the case where there are differences, the learning process involves making links to differentiate the two ways of explaining. For data analysis purposes, the present study explored the data in the lookout for link-making for integration or differentiation between the everyday and scientific ways of explaining.

Approach 2: making links between scientific concepts

This approach is based on the idea that in order for learners to adequately gain conceptual knowledge, they need to be aware of how different concepts fit together and are therefore applied connectedly to provide explanations to some scientific phenomena (Scott *et al*., 2011). It therefore involves making connections between different and somehow related concepts as a way of learning the new scientific topic/sub-topic. For instance, in conceptualising the concept of surface Area of a 3-Dimentional figure, learners need to be able to make connections between properties of any 2-Dimentional shape, calculation of their Areas (respective formulae), and the related arithmetic processes (place-value and measurements).

Approach 3: making links between scientific explanations and real-world phenomena

In this approach, the teaching-learning process takes the opportunity of realistic connections between the classroom-taught scientific concept and the actual real-life phenomenon which exists in learners' everyday life experiences (Scott *et al*., 2011). One appropriate instance from a mathematics teaching scenario could be in teaching and learning the concept of Perimeter, where its definition could be elucidated through the idea of the adequate length of fence required to cover a farm field. Another example could be learners' ability to relate and find the adequate number of floor tiles required to cover a kitchen floor by remembering the concept of Area of a 2-Dimentional shape. It is therefore important for the present study to focus on how teachers and their learners work towards making such links to develop learners' conceptual understanding.

Approach 4: making links between modes of representation

In this approach, the learner and the teacher focus on making connections between different modalities of representing a concept and make sense of how these representations work together to clarify the concept and its sub-concepts (Scott *et al*., 2011). These modes may include concepts such as algebraic equations, graphs and pictures. In the context of learning the concept of Area, for instance, the learners' conceptualisation may involve their ability to make links between graphical representation where Area becomes the counted number of squares in the graph or any figure and the algebraic formulae for each type of a shape. It is this linking between these representations and any other that may be possible that the present study was on the look-out to provide the learners' conceptual understanding of the concept of Area.

Approach 5: moving between different scales and levels of explanation

As articulated by Scott *et al*. (2011), this approach involves teachers' (and/or learners') ability to make links between explanations at different levels, "some of which are not directly visible". These levels include symbolic level, involving a variety of pictorial, algebraic and computational forms and representations; macroscopic level, which involves referring to students' spontaneous experiences; and (sub-) microscopic level, "comprising the particulate level, which can be used to describe the movement of electrons, molecules, particles or atoms") of explaining a scientific phenomenon (Scott *et al.*, 2011).

Though Scott *et al.* (2011) argued that this link-making theoretical perspective is fully applicable in all areas such as mathematics, the present study excludes this part of the link-making (Approach 5) since the mathematical topic Mensuration (Perimeter and Area of polygons) may not be easily analysed using it. For example, it is obvious that links may be made at symbolic and macroscopic levels of explaining concepts of Perimeter and Area, as discussed earlier. However, it is almost impossible to see any links made at the microscopic level in the teaching and learning of Area or Perimeter since these do not involve particulate nature of objects but concrete materials and those that exist in learners' tangible everyday experiences.

Approach 6: analogical link-making

This approach involves teachers making links between the targeted scientific (which may seem too abstract to comprehend) and a well-known/familiar real-life phenomenon (an analogue) which could help learners to better understand the concept (Scott *et al*., 2011). Though understood as 'less essential' in the development of deeper conceptual understanding, analogical link making may be used to help learners develop deeper understanding of some scientific concepts. For example, a teacher may use the concept of a fence around the farm yard as an analogy to further explain the concept of Perimeter.

3.1.2.2 Pedagogical link-making to promote continuity

This form of link-making is developed with the perspective that deeper learning and teaching of scientific concepts, occur over a period of time, be it days, weeks, months, years (Scott *et al*., 2011) or may be viewed in terms of lessons (prior/present/future) and experiences during such lessons. This is therefore seen as a way of promoting a form of intellectual continuity. As Scott *et al.* put it:

> In the classroom, pedagogical link-making to promote continuity may involve, for example, 'recovering' points of view raised in earlier lessons and further developing them or setting out the agenda for what is to be worked on in future lessons (p.14).

As indicated by Scott *et al*. (2011), there exist two approaches to link-making to promote continuity:

- *Approach 1*: to develop the scientific story; and
- *Approach 2*: to manage/organise.

Each of these approaches is accompanied by a time scale which is detailed by three levels:

- *Macro*: continuity links made on an extended time scale (typically of months/years), which involve making references to teaching/learning in different parts of the science curriculum;
- *Meso*: continuity links made on an intermediate time scale (typically of days/weeks), which involve making references to different points within a lesson sequence; and
- *Micro*: continuity links made on a short-time scale (typically of minutes), which involve making references to different points within a lesson.

These two approaches to link-making to promote continuity, together with the five approaches to link-making to support knowledge building, are accommodated in this study as part of the analysis process to observe how teachers involve learners in the process of link-making and hence determine their access to deeper conceptual understanding of each Mensuration concept discussed per lesson.

3.1.2.3 The question of Learner-Autonomy in link making: "who makes the links?"

The discussion in Section 2.1 brought to light the dichotomous existence of Active and Direct instructional approaches in the real mathematics classroom in relation to the present study. The above discussed link-making forms and their approaches are therefore played out over curricular duration where teachers execute instruction in each lesson content through either or both of these two instructional approaches. As discussed in that section, the concept of learner-autonomy seems to be more questionable when the teaching is dominated by processes of direct instructional approach. Similarly, in the process of link-making, it is important that the instructional environment allows learners to (or attempt to) make the said pedagogical links for and by themselves, as a way to maximise deep conceptual understanding (Scott *et al*., 2011). As they put it,

> …if deep understanding by the learner of an Area of scientific conceptual knowledge is to be the outcome of teaching, then it is necessary for the learner to carry out the process of link-making for themselves on the psychological plane. In this sense the learner has responsibility for their own learning (p.4).

This contention therefore brings to the picture the central focus of the present study, the concept of learner-autonomy, which is identified in this context by learners' ability and opportunities to make the pedagogical links for themselves hence allowing them to show the required responsibility for their own learning process. It is therefore understood that if this link-making opportunities are not often provided for learners, the concept of LA is compromised hence deeper conceptual understanding is highly likely to be compromised. Scott *et al*, (2011) was referring to this contention in saying:

> If the interactions of the classroom are focused solely on the authoritative presentation of scientific knowledge by the teacher, it is much more difficult for students to engage in a meaningful way with the content of the lesson and the mood of the class is likely to be suppressed (p.31).

In addition to exploring the types of instructional approaches (Active vs Direct) and forms of pedagogical links made in teaching/learning each Mensuration concept, the study provides conclusions towards the degree of LA by analysing the extent to which learners are given opportunity to make the pedagogical links themselves.

3.1.2.4 The Communicative Approach

In addition to the link-making processes and determining who, between the teacher and the learners, had more opportunity to make the links, the study further looked into how the teacher interacted with the learners as a way to support the conclusiveness of the discussions on LA. The idea of teacher-learner interactions therefore is viewed through the two dimensions of communicative approach, which scrutinise factors such as whether the teacher engages with learners in a dialogue and they evenly take part in the discourse, and whether the teacher accommodates and value learners' thoughts and ideas throughout the lesson (Mortimer and Scott, 2003).

Mortimer and Scott (2003) articulate the two dimensions of communicative approach as follows. The first dimension, *dialogic–authoritative* dimension, characterises the teacher-learner talk through two dichotomous approaches to the interactions: *dialogic* communicative

approach – which determines whether the 'teacher hears what the student has to say from the student's point of view'; and *authoritative* communicative approach – which determines whether the 'teacher hears what the student has to say only from the school science point of view'. In the dialogic approach, 'attention is paid to more than one point of view, more than one voice is heard and there is an exploration of ideas'. On the other hand, in an authoritative communicative approach, "attention is focused on just one point of view, only one voice is heard and there is no exploration of different ideas" (p.33 - 34).

The second dimension, *interactive–non-interactive* dimension, characterises the teacher-learner talk through the two approaches: *interactive talk* - in which the talk allows the participation of other people (for example, teacher accommodating learner's viewpoint); and *non-interactive talk* - in which the talk excludes the participation of other people (for instance, only teacher does the talking).

Mortimer and Scott (2003) combine these two dimensions to form four classes of communicative approach (summarised in Table 3):

- Interactive/authoritative communicative approach;
- Interactive/dialogic communicative approach;
- Non-interactive/authoritative communicative approach; and
- Non-interactive/dialogic communicative approach.

Table 3. Four classes of communicative approach
(*source: Mortimer and Scott, 2003, p.35-39*)

	INTERACTIVE	**NON-INTERACTIVE**
DIALOGIC	**Interactive/Dialogic** The teacher listens to, and takes account of, the students' points of view, even though these views might be quite different from the scientific view. The teacher and students explore ideas, generating new meanings, posing genuine questions and offering, listening to and working on different points of view.	**Non-interactive/Dialogic** Teacher acknowledges and makes reference of what students said and goes on to make his own point and explains without calling for any turn-taking interaction with the students. The teacher considers various points of view, setting out, exploring and working on the different perspectives.
AUTHORITATIVE	**Interactive/Authoritative** Teacher maintains communicative interaction but pays little attention to the students' ideas. The teacher leads students through a sequence of questions and answers	**Non-interactive/Authoritative** The teacher presents as if the students do not exist, in a lecture method, only teacher's voice is heard in the presentation.

	with the aim of reaching one specific point of view.	The teacher presents one specific point of view.

The analysis in the study therefore considers these classes of communicative approach in collaboration with the pedagogical link-making processes to determine how learners were led to take greater responsibility in their learning process (hence promotion of LA) and how the instructional environment fostered their deeper conceptual understanding of the concept under `discussion. For instance, on one hand, if the teacher creates opportunities for learners to make links between the *scientific explanations and real-world phenomena* in the teaching of Perimeter (Perimeter as sum of all sides of polygon and the idea of fence around the school yard), through an interactive/dialogic communication, then there are higher possibilities for learners to be autonomous and develop deeper understanding of the concept of Perimeter. However, if, for instance, the teacher is the one making the links in his explanations and mostly their voice is heard during such link-making, then the learners' autonomy may be compromised and they may not develop a deeper understanding of such concepts.

3.2 The Learner-Autonomous Mathematics Learning Environment (LAMLE) Framework

Having discussed the literature, curricular constructs and concepts from the two theoretical perspectives, I present the study-framing structure formed by corroborating these concepts. These concepts were incorporated with the aim of describing how the teaching and learning of mathematics can be executed if promotion of LA and deeper conceptual understanding were in focus. The study therefore used the concepts from this structure for the data analysis purpose. **Figure 1**below shows the LAMLE framework structure.

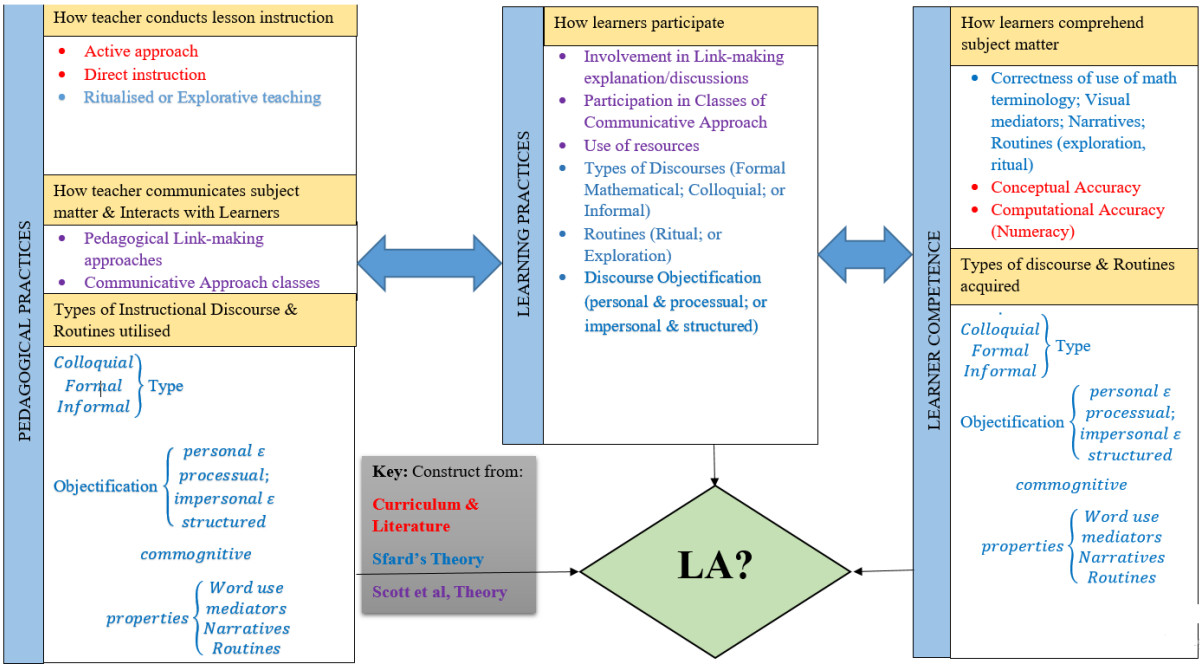


Figure 1. The LAMLE framework

Figure 2 shows a structural presentation formulated from three sets of concepts: concepts from the reviewed literature and curriculum (Red font); concepts from the Sfard's (2008) Commognition theory (Blue font); and concepts from Pedagogical Link-making and Communicative Approach by Scott *et al*. (2011) and Mortimer and Scott (2003) (Purple font). The interconnection of the sets of concepts is organised and titled into three units of observation (side-vertical bars): the Pedagogical Practices (which shows concepts which could be observed to describe how the teacher conducts the teaching process); the Learning Practices (which presents constructs which could be observed to describe how learners participate in their learning); and Learners' Competences (which shows constructs which could be observed to describe how learners show their understanding of concepts and their level of enculturation into Mathematical talk).

When viewed as an analytical tool, the LAMLE framework anchors the processes in the present study which could lead to the conclusive explanations on how the teachers' practices and learners' practices in each observed lesson promote the learners' autonomy in the learning and understanding of mathematics concepts. For instance, as discussed in prior sections of this chapter, if at some point in time during the lesson the teacher is observed to be using a teacher-dominated direct instructional approach, driven by his/her explanations in link-making through a non-interactive/authoritative communicative approach, it could be concluded that learners

were passively engaged hence no opportunities were created towards their autonomous learning. This could further be substantiated by the teacher's use of ritualised teaching which may be mostly led by the disobjectified (processual and personalised) colloquial discourses. Similarly, if learners could be observed to be reliant on the ritual learning routines, non-participative in link-making discussions, and somehow incompetent in terms of conceptual accuracy, procedural/computational accuracy, and problem-solving capabilities, the learners' incompetence could further be linked conclusively to the non-autonomous learning environment they have been exposed to.

In this way, the study would be conclusively responding to its main research question through its sub-research questions. Table 4 shows how each sub-research question maps onto the different parts of the LAMLE framework. The table therefore summarises the relevance of the framework to the analysis of the collected data and hence frames the study.

Table. 4 Mapping parts of LAMLE framework and the Sub-Research Questions

Research Question	Part of LAMLE Framework	
	Units of observation	**Constituent active concepts**
1: ***What types of instructional approaches (active vs direct) do teachers use in Grade 8 classrooms?***	Pedagogical Practices	**Curriculum & Literature:** Active instructional approach Direct instructional approach **Sfard's Theory:** Ritualised or Explorative teaching
2: ***What types of discourses and routines exist in these environments, when teaching or learning Mensuration?***	Pedagogical Practices Learning Practices	**Sfard's Theory:** Ritualised or Explorative teaching Mathematical or Colloquial discourses Discourse objectification Rituals vs explorations
3: ***How do these types of classroom discourses and routines relate to how learners understand Mensuration concepts (learners' competences)?***	Learning Practices Learner Competence	**Sfard's Theory:** Mathematical or Colloquial discourses Rituals vs explorations **Curriculum & Literature:** Conceptual Accuracy Computational Accuracy (Numeracy) Problem-solving
4: ***How do teachers and learners interact during the teaching-learning of Mensuration concepts (Perimeter and Area)?***	Pedagogical Practices Learning Practices	**Scott *et al*. Theory:** Pedagogical Link-making approaches **[Teacher]** Communicative Approach classes **[Teacher]** Involvement in Link-making explanation/discussions **[Learners]** Participation in Classes of Communicative Approach **[Learners]**
5: ***How do the Grade 8 mathematics teachers understand their role in the implementation of LAE oriented curriculum in teaching Mensuration?***	Pedagogical Practices	**Curriculum & Literature:** Active instructional approach Direct instructional approach **Sfard's Theory:** Ritualised or Explorative teaching

Table 4 is presented here as a more focused framework which guided formation of the base of analysis for all the data sets. The units of observation (column two) and the corresponding active concepts (column 3) were therefore used to form the themes and sub-themes which helped in the organisation of the research findings in Chapter 10. A total of three main themes were formed in line with these units and the research questions. These are: *(Theme 1*) Pedagogical practices (the observed, implied and the perceived); *(Theme 2*) Learner-learner discourses and routines, and competences in Mensuration; and *(Theme 3*) Teachers' role in implementation of curriculum. Theme 1 has been tiered into three sub-themes: Instructional Approaches; Instructional discourses and routines; and Pedagogical communicative interactions.

3.3 Conclusion

Chapter 3 presented the development of the conceptual framework which anchored the research processes in the present study. The framework was developed by corroborating three sets of concepts and their relevance to the central focus of the study - LAE in mathematics teaching. The three sets of concepts were selected from the reviewed literature and the curriculum; the Commognition theory; and theory of Link-making and Communicative approach. The latter two theories form the theoretical frameworks on which the development of the conceptual framework and the analysis of the data are based.

As the central focus of the study, learner-autonomy is envisioned here as a causative consequence of the three units of observation: Pedagogical practices; learning practices; and learners' competences. With pedagogical practices, the instructional environment could be concluded to have created (or not) enough opportunities for learners to be autonomous in the development of mathematical knowledge by observing: teachers' instructional approach used (active or direct); use of objectified/disobjectified mathematical/colloquial discourses, and rituals/explorations routines; learners' involvement in link-making discussions/explanations, and used classes of communicative approach (interactive/dialogic, interactive/authoritative, non-interactive/authoritative, or non-interactive/dialogic). In an ideal mathematics classroom situation, the teacher could be concluded to have created enough opportunities for learners' autonomous learning if he/she is observed to have used active instructional approach, objectified mathematical discourses and explorative teaching routines, and led learners to produce link-making explanations through interactive/dialogic communicative approach.

In the learning practices view, learners could be concluded to have demonstrated actions of an autonomously learning learner if they are observed to have participated in the link-making discussions or explanations through an interactive/dialogic communicative approach, have used explorative routines –,and objectified mathematical discourses –,while working on individual or group problems, and have shown problem-solving skills while operating with little or no dependence on the teacher's explanations.

The LAMLE framework therefore, was used in the study as the analytical tool to support the description of the pedagogical and learning practices observed and to indicate how learners understand the concept they have been taught, and how they indicate to have been enculturated into the mathematical communication.

Chapter 4: Research Methodology

4.0 Introduction

This chapter presents the study's research design; research population and sampling; context of the data collection sites; data collection instruments; data collection processes; data processing and analysis processes; validity and reliability aspects; and ethical considerations observed throughout the study.

4.1 Research Design

The idea of LAE was a radical concept in the Lesotho curriculum, hence the assumption was that not much was known by teachers and the research community on its implementation in Lesotho secondary schools. As such, after exploring several designs, I found exploratory research design, which employed qualitative research method, as the most appropriate for the present study.

According to De Vos *et al.* (2005), exploratory design applies where no basic information on a new area of interest is readily available, or "when there is a need to get acquainted with the situation so as to develop hypothesis" (p.106). De Vos *et al.* (2005) further indicate that exploratory designs generally take a qualitative approach. Therefore, the study used a qualitative research method to gain insight into the existence of LAE in classrooms, by looking into how learners were engaged, and how teachers understand their role in facilitating active learning and promoting LA as they implement the curriculum.

The study therefore adopted an interpretivist paradigm. The interpretivist paradigm emphasises understanding and meaning-making of a specific phenomenon in a social context, focusing on the subjective interpretations of individuals (Guba & Lincoln, 1994). This paradigm recognises that there are multiple perspectives and subjective experiences that shape people's understanding of the world, and it is premised in the belief that knowledge is created and negotiated through social interactions, language, and shared meanings (Denzin & Lincoln, 2011; Creswell & Poth, 2017). The study therefore adopted the qualitative research approach to adhere to and guided by the principles of this paradigm.

Within the interpretivist paradigm, the study used naturalistic inquiry to gather data from both learners and teachers. In naturalistic approach, researchers carry out observations in settings where the targeted practices and behaviours occur naturally (for example, during a regular class lesson) (Privitera & Ahlgrim-Delzell, 2019). The study gathered data through classroom observations, and learners' group discussions and problem-solving recordings (communication and written solutions) during normal classroom teaching times, and under the teachers' regular planned lessons.

4.2 Population and Sampling

The Grade 8 learners and their mathematics teachers in Maseru Central high schools were considered the targeted population for the present study, and the sample was selected from this population as presented in the following section.

4.2.1 Selection of Teachers

To collect the data for the study, five schools were identified as the most accessible sites. In each school, mathematics teachers were invited to voluntarily participate in the study. A further selection was done to end up with one teacher per school by looking closely into the teachers' attributes as indicated in the following paragraph. The target was to obtain one teacher from each school in order to control issues that may relate to the contexts and cultures of the schools.

Originally the study intended to use five teachers from the five different high schools in Maseru Central region. However, the fifth teacher who was selected had a very noisy and chaotic class, hence it was impossible to record the lesson proceedings properly. As a result, this teacher was eliminated from the study. The remaining four mathematics teachers from the four high schools were selected through convenience sampling method. Selection relied on how near and accessible their schools were to me and to each other. Convenience sampling "involves choosing the nearest individuals, from those who happen to be available and accessible at the time (for example, students)" (Cohen, Manion & Morrison, 2018, p.218). This was to ensure that most of the available time was used in data collection processes and to minimise travel times and costs.

The teachers were further selected purposively on the bases of their mathematics teaching experience (at least two years), mathematics teaching qualifications, and whether they were

teaching mathematics at Grade 8 at the time of data collection. This was to eliminate the element of inexperience. To avoid some data outliers, the teachers were selected such that those from the curriculum piloting schools were excluded. The study therefore used four teachers as part of the sample.

4.2.2 Selection of Learners

Though this was an exploratory study which involved whole-class observations, learners in each teacher's class were considered hidden participants when selecting their teachers. However, for the purpose of closer recording of the learners' discussions during the lesson observations, groups of four learners were purposely selected from each teacher's class through the help of the teacher. I therefore had a total of 16 learners selected for the group discussions data. To attain this number, an attempt was made to ensure that for these groups, learners with diverse cognitive skills were selected.

However, only two teachers were able to place their learners in groups according to this diversity, while the other two teachers just ordered their learners to work with anyone who sat next to them. I had to accept this group set-up to allow teachers to operate naturally. Therefore, for the latter two teachers, the learners were naturally grouped (that is, without consideration of any learner characteristics or any specific type of random selection) by their teachers to be part of the focus groups.

4.2.3 The Context of the Four Schools

In selecting the schools, a number of features were planned to be considered, including elimination of schools where the curriculum was first piloted before being distributed to the rest of the schools. Additional selection features included: variety of types of schools (church-owned, government-owned, and private-owned); history of the Junior Certificate candidate performance rankings (from best performing, medium performing, and poorly performing schools) for the past five years; and having an acceptable teacher-learner ratio per class, at most 1:50.

However, some of these planned school features were not possible to consider due to the timing of data collection (during the COVID-19 era). Most schools could not allow me to enter their classrooms due to their fear of COVID-19 infections. Therefore, I had to use only the schools

where I was allowed access. The contextual features of each of the four schools I used are discussed in the following sub-sections.

4.2.3.1 School A

This is an all-boys church-owned school located in a rural part of Maseru district. It is run by a functional school board, in which the principal is an active member. It is organised into departments, each led by a Head of Department (HoD). The Mathematics and Science Department had about six mathematics teachers (one female and five males) who were distributed among all the ten class streams (seven junior secondary and three senior secondary streams) such that each teacher was allocated at most two class streams per level. For example, the Grade 8 class was divided into three streams: Grade 8A, Grade 8B and Grade 8C, which were allocated to two mathematics teachers. Each of the Grade 8 class streams contained between 53 and 65 learners (that is, there were 53 learners in Grade 8A, 55 in Grade 8B and 65 in Grade 8C).

The placement of a learner in each class stream depended on whether they were new to the class or a repeater. For example, learners in Grade 8A and Grade 8B were all new to Grade 8 while those in Grade 8C were repeating the grade. The rules in School A were not so strict, hence teachers' ways of teaching and class attendance were up to the individual teacher's preference. The final assessment depended on only two quarters' (second and fourth quarters') performance. That is to say, the only formal examinations common to all class streams (for instance, all Grade 8 streams), were written only in June and in November, while all other times the assessments were only done by each individual teacher for their respective classes. In terms of the JC end-of-year examination results, School A could be classified as a Fairly Performing school.

4.2.3.2 School B

This is an all-girls school owned by a church congregation (Catholic Church Nuns) which has a functional school board in which the school principal is the secretary. It is located in urban Maseru town Central Area. The school is organised into different departments, each led by a Head of Department. The Mathematics and Science Department, in particular, had 9 mathematics teachers (3 females and 6 males) who were evenly distributed among 25 class streams (17 junior and 8 senior secondary). Each of the junior secondary classes contained between 50 and 65 female learners. The learners were placed in their respective class streams

such that they were evenly distributed in each class per stream according to their entry year's performance. For example, best performing Grade 8 learners were first all evenly distributed among the 6 class streams (Grades 8A to 8F), then finally the rest of the Grade 8 learners were distributed such that their numbers per stream were almost equal.

The Grade 8 class, in particular, was divided into 6 streams, each with a minimum of 48 learners and maximum of 55 learners (that is, there were 50 learners in Grade 8A, 55 in 8B, 55 in 8C, 48 in 8D, 52 in 8E and 50 in 8F). The mathematics teachers were distributed such that one teacher had a maximum of two Grade 8 streams. The promotion into the next level was based on the overall performance in the four quarters of the year in which the examinations were written at the end of each quarter. Besides that, there were some common monthly tests given. In terms of JC end-of-year results rating, the school could be classified as one of the Good Performing schools each year.

4.2.3.3 School C

This is an all-gender government-owned school located on the outskirts of the Maseru town. It is run by a school board, in which the school principal is an active member. It is sub-divided into different departments, led by HoDs, and 16 class streams, of which 4 were for the Grade 8 class (Grade 8A to Grade 8D). Each of the four Grade 8 streams contained between 54 and 67 learners (that is, there were 55 learners in Grade 8A, 54 in Grade 8B, 57 in Grade 8C and 67 in Grade 8D). The Mathematics and Science Department had 5 mathematics teachers (3 females and 2 males) who were distributed such that all the streams per class were taught by one teacher alone. For example, for the Grade 8 class, there was only one mathematics teacher allocated to teach all the four streams.

The learners were placed in their respective class streams according to their entry results at Grade 8. That is, those with the best grades were placed in Grade 8A, those with bad grades in Grade 8B and 8C, while the poorest performers and repeaters were placed in Grade 8D. The school had two promotional assessment sessions per year; first in June and the second in November. In June promotions, a learner with the best grades would stay or be promoted to the first and second class streams (either Grade 8A or Grade 8B depending on how good their grades were). The worst performers would then be demoted to lower class streams (either from Grade 8A to 8B or lower depending on how bad their grades were).

This therefore implied that in the second session, the first class stream (Grade 8A) would have the best performing learners while the last class stream (Grade 8D) would have the worst performing learners. During November promotions, the best performers would be promoted to the next grade first streams (to Grade 9A) according to their respective performance. The worst performers would then be promoted to the last class stream (Grade 9D) where they would join the repeaters. In terms of the JC end-of-year examination results, School C could be classified as Fairly Performing school compared to School A.

4.2.3.4 School D

This is a mixed-gender privately-owned school located in the urban Maseru Central region. It is run by a principal with assistance from a deputy principal and teachers. It is sub-divided into different departments, led by HoDs. The Mathematics and Science Department had 8 mathematics teachers (3 females and 5 males) who were distributed evenly among the 22 class streams, of which 6 were for the Grade 8 class (Grade 8A to Grade 8F). Each of the Grade 8 class streams had between 60 and 68 learners.

The learners were placed in their respective class streams according to their entry test results at the beginning of the Grade 8 year. That is, those with the best marks were placed in Grade 8A and in other Grade 8 streams according to how good their performance in the entry test were, hence the worst performers were placed in Grade 8F. The promotional common examinations were administered only once a year in November. On promotion to the next Grade (for example, from Grade 8 to Grade 9), learners from previous Grade streams would automatically be in the corresponding stream in the next grade (For example, those in Grade 8A would be promoted to Grade 9A). In terms of the JC end-of-year examination results, the school could be classified as a Fairly Performing school compared to School A.

4.3 Instrumentation

The study collected three data sets: *Whole class observations*, *focus groups* (speech and written work) and *teacher interviews*. For the classroom observations, I, as the researcher, was the main data collection tool (Pezalla, Pettigrew & Miller-Day, 2015). To cover issues of validity and accuracy of the data collected, I used video recording devices to gather data on classroom activities. This stems from the contention that audio and video recording of any session can be used for analysis of the proceedings of a session and can allow the researcher to concentrate on making observations during the session (Cohen *et al.*, 2018). For this purpose, I used two video

recording devices, one placed behind the class to capture the teacher's actions and overall class activities, while the other one focused on the selected group discussions. I later transcribed these videos verbatim.

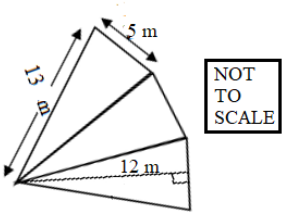
As a way of considering the ethical issues related to the use of video recordings, I placed one video recording device at the back of the class in each observed lesson per teacher. This was to ensure that learners' faces did not appear in the videos to maintain their anonymity and confidentiality. For the same purpose, I placed the other video recording device in front of the focus group such that it only captured what they were writing in their exercise books and recorded only their voices not their pictures. In my extracts in the data presentation chapters, I made sure that no learner or teacher could be identifiable from the snapshots presented by hiding their faces and identifying features where such could be identified. All the videos were saved in a password-protected device to protect the learners and teachers, in line with acceptable research ethics.

A set of interview questions (**Appendix A**) were prepared and posed to each of the four teachers. Those questions were designed to uncover, in depth, the teachers' perceptions of the curriculum and its expectations, and an understanding of their role in the implementation of the curricular expectations including LA. The questions included inquiry about teachers' understanding of the active instructional approach and LA, preferred teaching strategies, general curriculum implementation, and reflection on observed lessons. The interview questions included, among others, the following questions:

- What are the main expectations of the integrated curriculum, especially on the teaching strategies and learners' classroom behaviour and how do those compare with the old curricula expectations?
- Have you received any training prior to arrival of this curriculum in your school?
- What do you understand by active learning and teaching, and learner-autonomy in a Mathematics classroom?
- What role do you play in order to facilitate active learning in your Mathematics classroom?
- With your definition of learner-autonomy and active approach to teaching and learning, how would/do you teach Mensuration to help your students comprehend the topic thoroughly?
- To what extent do you think the learners were autonomous and actively involved in the learning processes?

As echoed by Cohen *et al.* (2018), the interview questions were posed to explore and probe teachers' verbal interpretation of the role of curricular-envisaged mathematics teacher in LAE (as proposed by MoET), from their own perspective.

Finally, a set of Mensuration problems (Appendix C**)** were developed (in consultation with teachers and an expert) and distributed to the learners' discussion groups in each observed lesson. The observation and video recording of group discussions occurred simultaneously with whole-class observations. The problem-set involved a real-life related problem and subsequent questions detailed as follows:

> Mr Stue has a yard in his farm where he keeps his animals. The yard is a 12-sided regular polygon. The diagram shows part of the yard in which Mr Stue keeps his sheep.
>
> 
>
>
> (a) Calculate the total length of fence required to enclose the part in which Mr Stue keeps his sheep.
> (b) Calculate the area of the yard occupied by all the animals.
> (c) Mr Stue wants to use the same length of the fence to reshape his yard such that it occupies a larger area.
> Describe the most suitable shape of the new yard Mr Stue can form. Support your description with appropriate reasoning.

The problem was set up to stimulate the discussion and interchange of ideas between learners as they interpreted and tried to come up with the solution to each subsequent question. By doing so, learners would be involved is some type of discourse which would indicate their learning routines, whether ritual or explorative. This would also indicate their level of understanding of the concepts of Perimeter and Area, whether that is deeper conceptual understanding coupled with computational accuracy, or procedural fluency or rote use of formulae without deeper understanding of the concepts.

4.4 Data Collection Procedures

The process of data collection occurred over two semesters of the secondary school year (semester 1: January-June; semester 2: August-November). It began with video-taped classroom observations. Data from whole-class observations and learners' group discussions was collected during normal classroom teaching sessions. This was to allow learners and

teachers to operate normally – as they would – in the absence of the observer. For each lesson, the proceedings of the lesson were video-recorded using two video cameras, whereby one camera focused mostly on the teacher's classroom actions and overall classroom activities, while the other camera, operated by an assistant, focused on the selected group of learners to record their discussions when they were given an exercise and problem-set to work on.

Each class was observed three times on different days (maximum of three weeks). In each case, the first lesson was observed only to familiarise learners and teachers with me (researcher) and the video recording devices [to attain normality]. This was also to test the functionality of my instruments, strategise on note-taking and locate appropriate spots to place recording devices. During the observation process, I focused on learner-learner, teacher-learner actions, conversations and general interactions in each lesson. These activities included speech; writings on learners' books and on classroom boards; and actions involving general learner-learner and teacher-learner interactions. These actions would therefore indicate teachers' preferred instructional approaches, discourses and routines, and accuracy of their board-written work.

Throughout the selected group observations, same-learner sets were used. This was to allow me to track their consistency in the types of discourses they engaged in. The groups consisted of only learners who were new to Grade 8 (not repeaters) to avoid discussion dominance by those who had studied the concepts before. In these groups I focused on their talk over the given problems given by the teacher and how they presented their work in writing. Their talk and writings would therefore indicate their preferred type of discourse and routines which would indicate their level of understanding of the concepts and accuracy of computational procedures.

The observation process was followed by teachers' semi-structured interviews. These were conducted to give teachers a chance to answer orally without the use of specific predetermined responses, and "allow follow-up questions to clarify and expand upon a response" (Privitera & Ahlgrim-Delzell, 2019, p.222). This allowed gathering of teachers' intrinsic perceptions about classroom teaching of mathematics in LAE, and their account on the teaching strategies used. Echoing Ono and Ferreira (2010), Qhobela and Moru (2014) insist that a critical reflection interview on the teacher's classroom practices is a form of intervention which can work as an element of professional development. The teachers' post-observation interviews in this study

were therefore intended to function as the critical reflection sessions meant to provide teachers with useful feedback on their instructional practices.

All the interview sessions were audio-recorded and later transcribed. The interview data was collected outside the classrooms whereby, for some teachers, the interview was conducted face-to-face and immediately after the last observed lesson, while for other teachers the interview was conducted through telephone calls in the evening of the last observed lesson day.

All the data collection processes were undertaken under strict caution and consideration of the COVID-19 regulations. During the classroom observations, I kept the recommended social distancing guidelines with the learners and the teachers. This included controlling the number and sitting patterns of learners in each group. Learners' desks were placed far apart from each other and the number of learners per desk was controlled. The learners, the teachers and I put on face masks all the time and each possessed hand sanitisers.

4.5 Data Processing and Analysis

Since this study used a qualitative research approach, all the data sets were analysed by following a deductive analysis method. According to Bingham (2023), deductive analysis involves applying predetermined codes to the data, whereby the codes are generated as concepts or parts of concepts collected from the reviewed literature, existing theory, or 'propositions that the researcher has developed' (p.2). As discussed in Section 4.5.2 below, the deductive data analysis deployed in this study used predetermined codes generated from different aspects.

All the data sets (whole-class observations, learners' group discussions and teachers' interviews) were first transcribed verbatim while narrating all other voiceless observed classroom actions. The data sets were processed all in the same way and the data coding and analysis were conducted through the deductive use of the codes developed as articulated in the subsequent sections.

4.5.1 The data-codes for deductive analysis (Codebook)

For the present study, sets of codes were prepared in line with each research question and each of the three units of observation from the conceptual framework in Figure 2, and from the partial analysis of the data from the Pilot study. The first step into the process of data analysis

was developing the qualitative data codes which included and was guided by the study's *units of observation (pedagogical practices; learning practices; and learners' competences)* as presented in conceptual framework structure in Figure 2. However, as a way to ensure operationalisation of the codes and their relevance in the analysis of the data, the codes were administered by coding the interviews and observations data of one of the teachers who participated in the Pilot study. This pilot data was also used to generate descriptions of each set of data codes classified under the three units of observation.

The final sets of codes under each of the three units of observation are:

1. **Pedagogical Practices**:
    - Active Instructional approach (AA);
    - Direct instructional approach (DI);
    - Formal Discourse (FD)
    - Informal Discourse (IFD)
    - Colloquial Discourse (CD)
    - Ritualised teaching (RR);
    - Explorative teaching (RE);
    - Pedagogical link-making: to support knowledge building (PL1, PL2, PL3, PL4, PL5, PL6 [for 6 approaches]); for continuity (PLa, PLb,));
    - Communicative Approaches (Interactive/dialogic (I/D), interactive/authoritative (I/A), non-interactive/dialogic (N/D), non-interactive/authoritative (N/A);
    - Discourse objectification (processual-personalised (PP), impersonal-structured (IS)).
2. **Learning practices**:
    - Link-making involvement (not-involved (LM0), involved (LM1);
    - Colloquial discourse (CD);
    - Communicative approaches (Interactive/dialogic (I/D), interactive/authoritative (I/A), non-interactive/dialogic (N/D), non-interactive/authoritative (N/A));
    - Discourse objectification (processual-personalised (PP), Impersonal-Structured (IS));
    - Routines (Ritual (RR), Exploration (RE))
3. **Learner competences**:
    - Discourse objectification (processual-personalised (PP), Impersonal-Structured (IS));
    - Routines (Ritual (RR), Exploration (RE));
    - Conceptual accuracy (CA1);
    - Computational accuracy (CA2).

The three sets of data codes therefore align closely with the aspects of the conceptual framework guiding the study, and the study's research questions. These codes and their descriptions with examples are shown in **Appendix J.** It should be noted that the codes used for analysis in the main study are somehow different from those used in the Pilot study. As discussed in Chapter 5, this is due to the change that had to be done in the theoretical frameworks as a result of the pilot processes.

4.5.2 Classroom observations

The transcribed lessons proceedings were processed and analysed, with the aim of determining the teachers' instructional approaches, learners' competences, types of discourses, routines and overall types of interactions in the classroom. These included teachers' actions and activities which characterised their respective pedagogical practices, paying special attention to repetitive patterns and also variations regarding the important aspects of each set of activities and each concept of Mensuration taught. The learners' discourses and activities, and their teachers' actions (and talk) were revealed from the transcriptions, by deductive coding with the codes described above.

This process began with a thorough reading of the transcripts from the observations of each teacher's class. This was done concurrently with making commentary notes in the margins, to describe the observed actions. An example of the notes making is provided in Figure 3.

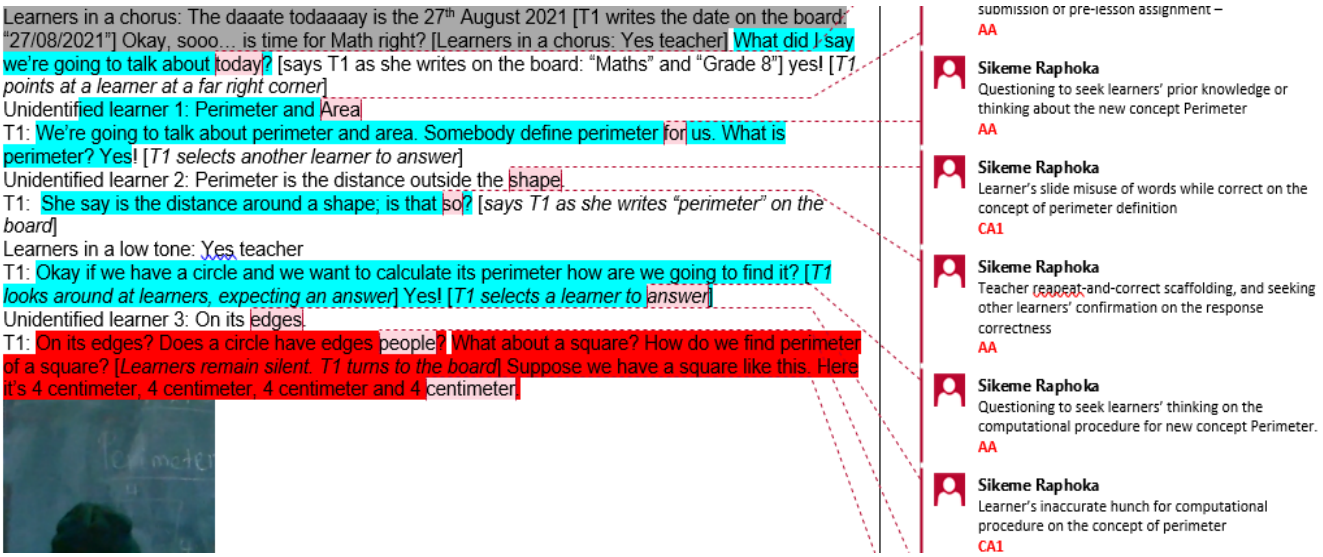


Figure 2. Example of analysis notes writing and coding

The next step was the coding of the segments of data for each teacher using the codes (colour coding and letter coding), while accommodating any emergent data codes and categories from the transcripts. The coded segments of data were therefore aligned with the notes to help in the description of each teacher's classroom practices, learner-competences, classroom discourses and routines, and teacher-learner interactions, while learning about the existence and importance of the study's central focus - LAE.

Likewise, the learners' discourses and routines observed during the whole-class observations were coded and interpreted according to how they revealed learners' understanding of Mensuration concepts, and how objectified such discourses were. The coded segments of the transcripts were then discussed according to how they conformed to the two types of classroom discourses, Colloquial and Formal/mathematical, and how objectified they seemed to be, with respect to the concepts of Mensuration taught. The learners' actions during each lesson were also coded and discussed according to how they participated in the link-making explanations or discussions, and the forms of communicative approach they seemed to be involved in.

4.5.3 Learners' problem-set discussions

While using the same predetermined codes, the data segments from learners' discussions –, supported by their writings –,were coded and interpreted according to how they characterised the learners' competence level, and the objectification level of their discourses (structure vs processual and personalised vs personalised). The data segments from the learners' discussions were further coded and presented according to how they reflected the types of routines (rituals vs explorations) learners were utilising as they worked on the problem-set and textbook exercise.

4.5.4 Teachers' interviews

The processing and analysis on the teachers' interviews data followed the same method as the analysis on the observations data. It began with reading through the transcripts of teachers' responses to spot the teachers' practices and perceptions as described by them. The spotted teachers' actions were then coded and described. The selected data segments were then given interpretation which best described the teacher's pedagogical practices, especially instructional approaches, and how they understand their role and the curricular expectations. Selective coding is the final organisation of data codes in which data categories are organised to articulate an understanding to a phenomenon (Privitera & Ahlgrim-Delzell, 2019).

The teachers' actions and talk from the observations and interviews data were finally consolidated and compared with the aim of describing each teacher's pedagogical practices and interpret how they understood their role in facilitating the learning process. The data presentation and analysis for each teacher's class is presented in detail in Chapters 6 to 9. The summarised analysis for each learner-group discussion and pedagogical practices of each teacher are presented in **Appendices K** to **R.**

4.5.5 Data Presentation and Thematic Presentation of the Findings

As part of the analysis of all the sets of data, the data from each of the teacher participants and their learners is presented narratively in Chapters 6, 7, 8 and 9; each of these chapters representing a case for a particular teacher. In each part of the presentation, the data is interpreted in accordance with the study's units of observation which were used to design the data codes for analysis purpose. The purpose of presenting these data sets in this manner was to allow closer look into each teacher's pedagogical practices, how they execute their role as implementers of the curriculum, and how these compare and relate to their learners' discourses, routines, and competences in each of the observed lessons.

The thematic presentation and discussion of the findings, resulting from the collective studying of all the interpretations from the four chapters, is presented in Chapter 10. This was to allow a further comparison and contrasting of the four teachers' pedagogical practices, learning practices of their learners, and how each describe their perceived roles in the implementation of the reform-oriented curriculum. This comparison therefore allowed me to generate conclusive responses to the main research question and the purpose of the study towards the type of instructional environment which learners were exposed to and how that relates to LAE. As stated in Chapter 3, the findings are presented under three themes: *(Theme 1*) Pedagogical practices (the observed, implied and the perceived); *(Theme 2*) Learner-learner discourses and routines, and competences in Mensuration; and *(Theme 3*) Teachers' role in implementation of curriculum.

4.6 Reliability and Validity

In qualitative research, Cohen *et al.* (2007) suggested the notion of '*trustworthiness'* as a replacement for the conventional views of reliability and validity, and that this notion is

"devolved on issues of *credibility, confirmability, transferability* and *dependability*" (p.158). I use these four concepts to address the element of trustworthiness in the present study.

4.6.1 Credibility

Credibility in a qualitative research is regarded as alternative to internal validity, and the objective of checking it is to signify that the inquiry has been conducted in a way that ensures that the "subject is accurately identified and explicitly described" (De Vos *et al.,* 2005; p.345). To address the credibility of this study, three essential aspects were considered: triangulation; member checking and peer debriefing.

4.6.1.1 Triangulation

The data on learners' discourses, routines and interactions was gathered through video and audio recordings of their communication and their writings in problem-solving tasks. Likewise, data on teachers' pedagogical practices was gathered using both classroom observations and interviews. This stems from the contention that gathering multiple types of data using different instruments (such as observations and interviews) is a form of triangulation called data-triangulation (De Vos *et al.*, 2005; Privitera & Ahlgrim-Delzell, 2019).

4.6.1.2 Member checking

After each observed lesson, each teacher was given an opportunity to re-watch the video recordings ahead of the interview session. This exercise was intended to offer teachers an opportunity to demand that anything non-satisfactory be deleted. It allowed corrections of factual errors, offered participants the opportunity to add further information or "to put information on record" (Cohen *et al.*, 2007, p.136).

4.6.1.3 Peer debriefing

I requested some of my PhD colleagues to read through my findings and examine the methods used as a way of testing honesty in the report that would emerge from the findings. This exercise was also done repeatedly during peer presentations with my study group, which we conducted online, and regular presentations during PhD research weekends. I also requested an English language expert to proofread my interview questions and the entire thesis document to correct language errors and offer editorial advice.

4.6.2 Confirmability

To address the issue of confirmability on the observations and interview data, all observation sessions were video-recorded and interviews were audio-recorded to allow audit trails whenever necessary. In my data presentation and findings, extracts of raw data for each episode of learner-learner and teacher-learner conversations are provided as they occurred. In my data presentation and findings on interviews, I provide the teachers' responses for each interview question posed verbatim.

4.6.3 Dependability

To ensure dependability, one more aspect, persistent observation, was considered in addition to the aforementioned (triangulation; member checking; peer debriefing; and independent audits). Persistently videotaped classroom observations, which were done three times per class, were part of the attempts to increase the dependability aspect of the study findings. This was to allow the learners and their teachers to get used to the observation process, the observers and the recording devices.

4.6.4 Generalisability

According to Leung (2015), qualitative research is mostly meant to study a specific issue in a specific localised population of a particular context. Therefore, *generalisability* of qualitative research findings is usually not a clearly understood concept. However, generalisability in qualitative research can be accounted for by interpretation in terms of *comparability* and *transferability* (Lincoln & Guba, 1985). *Transferability* is defined as the degree to which the results of the study can be transferred to similar situations (Barnes, Conrad, Demont-Heinrich, Graziano, Kowalski, Neufeld, Zamora & Palmquist, 2012). Barnes *et al*. (2012) articulate that research readers note contextual specifics of a study to test similarity with their own. If there exist enough similarities to their context, inferences may be made that the readers' study will yield a similar outcome.

In the present study, I utilized purposive selection of participants (see Section 4.2.1) and provided a thorough description of the research context for each participant (see Section 4.2.3), methods and findings in all the phases of the study. The contextual details of the data sites and participants are highlighted to allow readers to make a much more informed judgment whether they can transfer the findings or methods to their own contexts.

4.6.5 Validity of learners' problem-set

The validity of a written test material depends on its similarity with pre-existing similar peer-reviewed materials and familiarity to the experts in the field in which such document exists (De Vos *et al.*, 2005). To address internal validity of the learners' problem-set, its questions were developed in collaboration with experienced mathematics teachers who teach Grade 8 and upper grades. A mathematics subject specialist was consulted to ensure the questions were accurate in terms of difficulty level, syllabus relevance, wording accuracy and construct measurement. The problem-set was also used in the Pilot study, hence was re-edited, to address observed ambiguities and errors, and to suit the Grade 8 learners' level of comprehension before they could be used in the main study.

4.7 Ethical Considerations

For an educational research study, which involves interviews and observations of human participants, it is vital that a number of ethical rules are set and considered as a norm. These include, but not limited to: informed consent; providing enough information to participants about the research study; discussing clearly the possible consequences of the research with participants; naming the people who will have access to and benefit from the research; how the participants will benefit from the research; participants' right not to participate; and permission from the school and/or parents (Cohen *et al.*, 2018).

For the current study, a formal Ethics Clearance Application to the Ethics Committee of the Wits School of Education was made, hence a clearance certificate was obtained. In addition, permission was sought from Lesotho's Ministry of Education and Training (MoET) in writing (**Appendix E**) and from the principals of the selected schools (**Appendix F**), and was granted in writing (**Appendix N**), to conduct a research study in the chosen schools [The written permission letters from each school are not displayed as Appendices to hide the identity of the schools]. Teachers and learners were recruited on voluntary basis. Participants' consent letters (**Appendices G** and **H**) were prepared (and checked by my supervisor) and discussed with teachers and learners prior to administration of classroom observations and interviews. The consent forms were signed with the participants and each kept a copy. During all data collection processes, conscious attempts were made to ensure participants' comfort and willingness to participate.

To control the ethical issues related to the use of video recordings, I placed one video recording device at the back of the class in each observed lesson per teacher. This was to make sure that

learners' faces did not appear in the videos to maintain their anonymity and confidentiality. For the same purpose, I placed the other video recording device in front of the focus group such that it only captured what they were writing in their exercise books and recorded only their voices not their faces and pictures. In extracts in the data presentation chapters, I ensured that no learner or teacher could be identifiable from the snapshots presented by hiding their faces and identifying features where such could be identified. All the videos are saved in a password-protected device to protect the learners and teachers.

The information reported in this study maintains anonymity of participants (actual names of schools, and those of participants - the names used were invented by the researcher for presentation of data, and discussion of the findings). The data gathered from the participants was used solely to inform the topic of the study. The raw data was stored safely in a digital drive, Microsoft-OneDrive and on a computer laptop with restricted access till it is erased completely after an acceptable period beyond completion of the study.

4.8 Conclusion

The present study investigates the types of instructional environments created by teachers as they teach concepts of Mensuration, Perimeter and Area. It therefore adopted an interpretivist paradigm, which allowed the discussion of the central focus of the study, LA, as a conclusive causative construct of the study's three units of observation: pedagogical practices, learning practices, and learners' competences. The qualitative approach employed in the study involved classroom observations (whole-class observation of teacher actions, and group discussions), and teachers' interviews, all with the purpose of interpreting the classroom events to produce conclusive narratives of teachers' practices and learners' practices on the concept of LA in mathematics education.

Through purposive and selective sampling, the study used four mathematics teachers and a group of up to four learners from each teacher's class. The selective analysis followed a deductive coding process which began by generating the codes from the conceptual framework designed to address all the units of observation. All the processes undertaken in the study followed research ethical considerations to ensure and maintain the minimal risk level for the participants.

While all the methodological processes in the study served the previously proposed purpose, a Pilot study had to be conducted as a way of ensuring smooth implementation of such proposed processes and to address the validity and reliability issues. The processes and the outcome of the Pilot study are presented in Chapter 5 below.

Chapter 5: The Pilot study

5.0 Introduction - What was proposed

At the proposal level, the study aimed at exploring the nature of classroom environments created by mathematics teachers as they implemented the proposed curriculum. This included looking into the lesson proceedings and investigating how such environments emulate the learner-autonomous environments. The proposed study thus aimed to answer the following research questions:

Main Research Question:

What is the nature of Grade 8 classroom environments created by mathematics teachers as they implement the integrated curriculum, which calls for LAE (focusing on Mensuration)?

Sub-questions:

1. What types of classroom environments exist in Grade 8 classrooms and how does it emulate LAE?
2. What types of discourses are dominant in these environments, when learning Mensuration?
3. How do these types of classroom discourses influence how learners understand Mensuration concepts?
4. How do the Grade 8 mathematics teachers understand their role in implementation of LAE oriented curriculum in teaching Mensuration? 5. What types of learner engagements are evident in these classroom environments?

In attempting to answer these questions, the study proposed a number of methodological processes and tools. These are presented below.

5.1 Methodology

5.1.1 Sample selection

For the purpose of piloting the data collection instruments and data processing operations and tools, two schools were identified from two districts in Lesotho, Mafeteng (School 1) and Maseru (School 2). These schools matched the selection features of the schools targeted for the main study, such as accessibility and type of school (for example, privately-owned or church-owned). Two Grade 8 mathematics teachers (Teacher 1 and Teacher 2) were invited to voluntarily participate in the study; one from each school. In addition to their voluntary

participation on invitation, selection of these teachers further relied on their teaching experience (at least 2 years), their mathematics teaching qualification and whether they were teaching Grade 8 mathematics during the piloting process in their schools. In each of these schools, the two teachers who became the sample for the study were the only ones who agreed to participate and had the required characteristics.

Learners comprising groups of four were selected from each teacher's class by each teacher. The pilot therefore involved a total of eight learners who were selected as focus groups from which the researcher would record the discussions during the lessons or during problem-solving sessions. An attempt was made to ensure that the groups were formed to represent learners' diversity in mathematics achievement (best to worst performing learners). However, this was not possible with Teacher 2, due to his preferred group setting (letting learners choose their own groupmates). Since the data would be collected while the lessons proceeded under normal setting, teachers arranged all the learners in groups for the problem-solving session prior to the session in each observed lesson.

5.1.2. Instrumentation

The pilot collected three data sets: whole-class observations; learners' group discussions (speech and writings); and teachers' interviews. For observations, I used summarised field notes and video recording devices. These videos were later transcribed selectively. The observations were limited to the teacher's overall classroom actions, teacher-learner discourses and routines, and learner engagements observable in each lesson. During the observations, an attempt was made to use an observation tool which consisted of pre-determined constructs which would be observed and marked on the tool as they occurred. However, the use of a tool seemed to hinder my focus on the video recording device and teachers seemed to be distracted when they realised that I was ticking some items on the form as they were teaching. Therefore, I chose to abandon the tool and instead used simple short note-taking. Further, the plan was to use three video recording devices to accommodate all other classroom activities. This was not done since the two recording devices (video cameras) were enough to record overall classroom activities and the activities of the selected learner groups.

A set of interview questions were posed to each teacher to explore in depth their verbal interpretation and understanding of the role of curricular-envisaged mathematics teacher. The interviews were conducted after the last observed lesson as a reflection on the observed actions

during each lesson. The questions included: inquiry about teacher's knowledge and perception on curricular expectations; purpose of teacher's activities; instructional approaches, including active instructional approach and learner-autonomy; and teacher's understanding of their role and expected learner practices during mathematics teaching. The interviews were audio-recorded and selectively transcribed.

Guided by the answerability of the questions during the interview sessions, the questions were edited to ensure smooth interview sessions in the main study. The editing included removal of follow-up questions and restructuring of each seemingly ambiguous question, and removal of irrelevant questions. **Appendices A** and **B** present the first and final drafts of the interview questions.

A set of Mensuration problems were distributed to learner groups during each observed lesson. These were set to trigger learners' discussions and to enable evaluation of their types of discourses and routines, and understanding of Mensuration concepts. However, two of the teachers claimed that the questions were too complicated for their learners hence they used the questions from the learners' textbook for the learners' activity. For the teacher who used the prepared problem-set, I realised that learners could not attempt all questions and some had a problem with the diagram in the first question. I therefore edited the diagram by relabelling the dimensions and reduced the number of questions. The first and final drafts of the problem-set are shown in **Appendices C** and **D** respectively.

5.1.3. Data collection processes

The video-taped whole-class observations and learners' group discussions data was collected concurrently during normal classroom teaching. The audio-taped interview data was collected after the last observed lesson for each teacher. The process of data collection occurred over four weeks for the three teachers.

Each teacher was observed in two lessons, each on Perimeter and Area respectively. However, each teacher's class was visited once before the actual data collection lessons. In each case, this first visit was to familiarise learners and teachers with me and the video recording devices [to attain normality]. This was also to allow me to identify the selected group of learners, test the functionality of instruments, strategise note-taking and locate appropriate spots to place recording devices. During the observations, I focused on the teacher's actions, and classroom

communicative interactions in each lesson. These included speech; writings on learners' books and classroom board; actions involving general interactions.

As part of the audio and video recordings, two video cameras were used, one placed at the back of the class (behind the learners) to capture the teachers' activities and movements around the class. The second camera was mounted near the selected group of learners to capture their activities during the problem-solving or learner pen-paper activity. Since classroom activities could involve movement and spontaneous communication and writing, both cameras had operators (my assistant and I) to twist and turn the cameras accordingly. Each of the observed lessons, including the first visit, took a 40-minute period.

Semi-structured interviews were conducted to give teachers a chance to answer orally without dependence on specific predetermined responses, and because they "allow follow-up questions to clarify and expand upon responses" (Privitera & Ahlgrim-Delzell, 2019, p.222). This allowed gathering of teachers' intrinsic perceptions about classroom teaching of mathematics in an active and LAE-structured classroom, and their account of observed practices. All the interview sessions were audio-recorded, one over a cellular phone call and the rest face-to-face.

5.1.4 Data Analysis

For the purpose of piloting the study's analytical tool, I conducted a selective analysis of all data sets. As a preliminary step in the process of analysis, the Pilot data was partially used to generate the data codes and to provide appropriate examples for the description of each code. For data analysis, the proposed study was planned to use an analytical framework designed by selecting appropriate concepts from two theoretical perspectives (Sfard's (2008) Commognition, and Reeve's (2013) Engagements), curricular expectations and literature. The proposed analytical framework is presented in Figure 3 and as **Appendix I.**

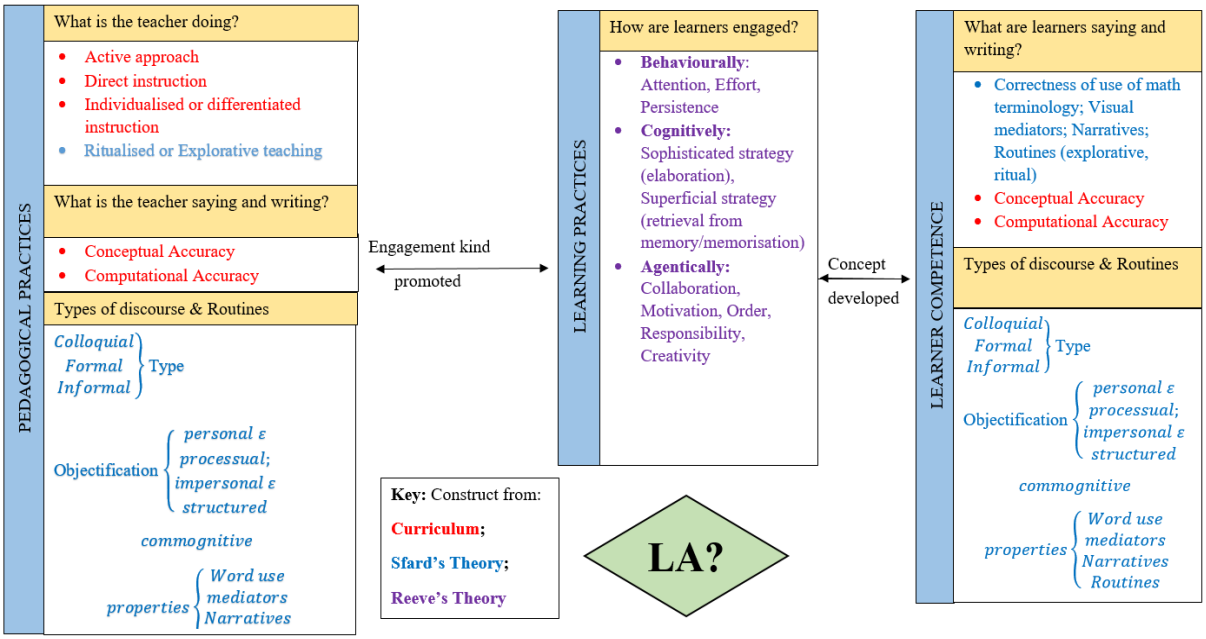


Figure 3. The Proposed Analytical Framework (old version)

The codes used for pilot analysis were structured from this framework depicted in Figure 3. The final codes were:

Instructional approaches: Active instructional approach (AA), Direct instructional approach (DI), Individualised/Differentiated instruction (ID);

Engagements: Behavioural Engagement (BE), Cognitive engagement (CE), Agentic engagement (AE);

Discourses and Routines: Discourses (DS), Discourse objectification (DO), Routines (Ritual-RR, Exploration-RE), conceptual/computational accuracy (CA).

The analysis process followed a thorough reading of transcripts, while making commentary notes in the margin to describe the observed or reported practices. An example is provided in the snapshot below.

-So, ka mofuta ona oa nnyeo, they want pupils to be autonomous and they should be actively engaged, right? So what do you think should be your role ka har'a class eo e joalo? In this kind of a class where learners are autonomous and they're actively engaged? What should be my role as a teacher?	-Mmm... My role as a teacher; if I've sat these learners in some groups and they're all engaged, I think my role is just to go around facilitating what they're doing.
-Yes sir, yes sir, okay	-Eya ntate
-Okay, So we're already on this thing. Let's say, yes we have this kind of a class whereby learners are autonomous, eh how would you, as a teacher approach the nnyeo, akere oa tseba bana ba na le different ways if learning? **(Mary's T1: Mmh)**, eh some of them are people like me they don't even raise up their hands in a class, they don't talk at all, they just listen to the teacher you know. Some of them they are this kind that	-Mmh (clears throat) mmm...I think as you're saying, hore ba bang ba tla be ehlile ba hloka hore u tla bo bua ebe ba mametse, ke hona ba tla be ba capturile. Ba bang ehlile ba tla hloka hore ebe ba entse li group joalo ba hands-on, o tlo tla a utloa hantle ho feta nakong eane a tla ba hlalosetsoa ke e mong.

Sikeme Raphoka
Facilitator role
[AA]

Sikeme Raphoka
Some learners have to seat quietly and lister
that way they will understand.
[DI]

Sikeme Raphoka
Other learners understand better when cond
explained by others when participating in gr
[DI]

The next step was the coding of the segments of data for each teacher, while accommodating any emergent codes and categories. The coded segments were therefore aligned with the notes to help with description of each teacher's classroom practices, learner-competences, classroom discourses, and engagements.

5.1.5 The Pilot Findings

The preliminary findings are presented as selective discussions structured in terms of: instructional approaches observed; discourses and routines; learners' types of engagements, and competences. The two teachers showed a number of aspects in which their teaching was similar and some where they were operating differently. However, they could not be concluded to be completely different or similar at the superficial level since their operations varied according to the concept taught.

The analysis revealed Teacher 1's operation as active instructional during his lesson on Perimeter. He led learners through question-answer interaction to help them provide explanations on the definition of Perimeter. He also led the class to review properties of shapes through some leading questions, and provided examples while allowing learners to work on it and provide answers. While this question-answer operation existed, Teacher 1 also displayed actions of direct instructional approach when he provided and demonstrated computational procedure on Perimeter with examples, leading learners with confirmatory questions through the arithmetic process. In addition, he provided a thorough summarising explanation of definition and computational procedure of Perimeter (see example in the extract below).

01: T1: You start at this corner and you want to measure the distance around this shape, what will be distance around this rectangle?
02: L1*:* 22cm
03: T1: And how do you get 22cm?
04: L1: We add all sides together.
05: T1: So we're going to add all four sides together. Let's start with this one; we have 5cm plus the next side which is 6cm plus 5cm plus the last one which is also 6cm. Then adding these four what do you get?
06: Learners in a chorus: twenty-two
07: T1: Twenty-two centimetres, [*he writes on the board: 5cm + 6cm + 5cm + 6cm = 22cm*] …and this 22cm is the distance around the shape, and we called it Perimeter. So to calculate the distance around a given shape, that will give you Perimeter, and to calculate it simply you have to add all measurements that you are given on the shape that will give you the Perimeter.

Though the teaching was conducted through a learner-engaging question-answer interaction, the questioning only demanded learners to narrate the procedure used while lacking some probing for learners to substantiate their answers. This therefore was the teacher's ritual performance geared to lead learners' memorisation and rote use of taught and demonstrated formulae. This ritual was also visible in the teacher's use of processual and personalised discourse. This act of drilling learners to memorise the formulae and perfect its use indicated his superficial strategies for learners' cognitive engagement.

Teacher 1's teaching took a more direct instructional approach in the second lesson where he was teaching Area. He introduced the lesson by reminding learners the formula for calculation of Area of rectangle by telling. He further introduced the formula of Area of triangle by explaining while cutting the rectangle into halves by drawing diagonal lines hence explaining and writing that Area of triangle will be Area of rectangle divided by two. The formula therefore was written as half by length by width and later as half base by height while telling that it is the simpler version of the formula. The installation of this new formula was enhanced by providing a worked example to demonstrate how the formula works. Learners were however included by leading probes through an arithmetic process as the teacher worked and explained using the example. They were further engaged by working on the given exercise on Area of triangle as a way of practising using the formula they had just been taught. These actions indicated the ritual nature of the teaching and superficial strategy in engaging the learners.

Teacher 2 (T2) acted a bit differently from Teacher 1 in his teaching since, in both lessons, he used a direct instructional approach. In the lesson on Perimeter, T2 introduced Perimeter by telling learners its definition while referring them back to the definition of length. Learners were involved by only providing a choral *'yes sir'* response to the teacher's *'right?'*

confirmatory, which followed every explanation provided by the teacher (see the extract below).

> **08: T2:** So now let's look at the Perimeter. *[T_1 writes on the board: "Perimeter"]* So when you're talking of Perimeter that will be the distance around any shape, right? The total distance around a closed shape, that is a?
> **09: Learners in a chorus:** Perimeter!
> **10: T1:** Perimeter! *[T_1 writes on the board: "total distance" below "Perimeter"]* Here we'll be looking at the total distance, the total length. Remember we have been talking of a length, which we said it will be the distance in-between two points right?
> **11: Learners in a chorus:** Yes, sir.
> **12: T2:** So for a Perimeter it will be the total length around a shape, right?
> **13: Learners in a chorus:** Yes, sir.

Learners were therefore subjected to memorising the definition and its relation to the concept of length as their knowledge development strategy. This kind of presentation indicates T2's teaching as less interactive and engaging learners in superficial strategies for their cognitive engagement. The teacher further provided learners with explanations and computational procedures for the concept of Perimeter, with a demonstration in a series of examples to illustrate how such procedure works. At this point, learners were involved through leading questions over the arithmetic process as the teacher procedurally worked on the examples. This further showed learners' superficial engagement and the teacher's ritual to allow learners to memorise the definition and computational procedure hence perform it similarly to him.

Teacher 2 also displayed actions of direct instructional approach in his teaching of Area. He introduced the concept by a direct reminder by telling learners the formula for Area of rectangle as length times width. This was immediately followed by his unidirectional presentation on how the Area of a triangle derives from the Area of a rectangle. He cut the rectangle into halves with a diagonal line hence showing and telling learners that the Area of the triangle is half base times height. Learners only participated by providing a *'yes sir'* answer to the teacher's *'right?'* confirmatory. To emphasise the functionality of the formula and demonstrate how it works, T2 provided examples with different triangles, while presenting to learners how to identify the height and base of any triangle by telling and demonstrating in those examples.

This presentation was a further indication of T2's ritual performance, where the teacher acts as the sole bearer of knowledge and explains to the learners, the rules and procedures to be followed and learners memorise and perform accordingly. It further indicated the teacher's

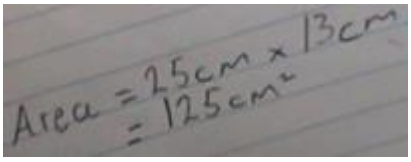
engagement of learners through superficial strategies which involve memorisation and rote use of the demonstrated procedures and formulae.

In both teachers' classes, learners were exposed to ritual routines and superficial knowledge attainment strategies (characterised by memorisation and rote use of procedures and formulae) at some point during the two observed lessons. This therefore could be equally substantial to the observed incompetence of learners, in both classes, in terms of lack of conceptual understanding, computational accuracy, ritual performance, and disobjectified discourses. In some instances during each lesson, each of the two teachers provided learners a problem (or exercise) to work on as an evaluation or drill to practise or show understanding of taught concepts.

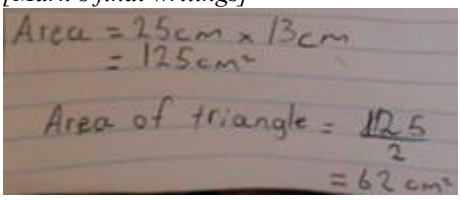
In Teacher 1's class, two learners (Mark and John) were working on a textbook activity in which they had to find the Area of a rectangle of sides, 13cm by 25cm. They seemed to have well memorised the formula (length multiplied by width), given by the teacher. They however made a computational error, getting 125 as the product of 13 and 25. They were convinced that this product was correct, hence they proceeded to the '*second*' part of '*the procedure*', a division by 2 (as explained and demonstrated by the teacher). If Mark and John had a deeper understanding of the concept of Area (with distinct formula per shape type), they would have realised that they had reached the end of their solution after getting 125.

However, since they had memorised the procedure so *'well'*, yet they could not select appropriate situations to which these procedures were applicable; they proceeded with all the steps of the teacher's *'procedure'*. This was reflected in their attempt to divide their 125 by 2 since that was what they saw the teacher doing. Their emphasis, that they had to use 2 because it was a '*method*', showed that their routines were rituals since they saw the need to conform to what the teacher had given to them as the only way of working out the Area. They considered the division by 2 as the 'method' (a ritual) that should always be followed whenever working with an Area problem. However, they could not make a connection between the division by two and use of a half (hence they agreed to drop the idea of a half) – an indication of lack of numerical knowledge (see extract below).

14: Mark: 25 times 13 is how much? It's 125
15: John: Yes, it's 125
[John writes:]

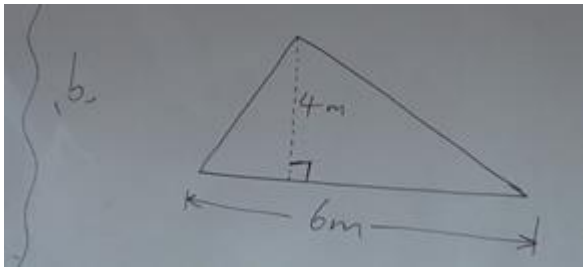


16: John: 125 square centimetres, then we go to that part where we say Area of triangle equals Area of rectangle then we divide by 2.
17: Mark: Were we told that?
18: John: Yes…you saw him right…? It's just that he erased it there…I would show you. Area of a triangle…our Area is here right? [*Points at 125cm²*]
19: Mark: Yes!
20: John: It means we will say 125 divided by 2.
21: Mark: Why divided by 2? …
22: John: … yeah, yeah because it's a method… we should always divide by 2. So for me the hard part is here where we are now using the halves. I think it is going to be too long when we do that.
23: Mark: Hey man, let's leave alone this one of halves… it will be like this
[Mark's final writings]



This presentation showed the learners' lack of conceptual understanding and computational accuracy, and their strong memory of the procedure which the teacher presented as a link between two formulae. This also indicated that the learners' routines were purely rituals since in addition to 'unconsciously' following the teacher's procedure as is, they even referred to what the teacher said and did (or had written on the board) as their only reason for their action.

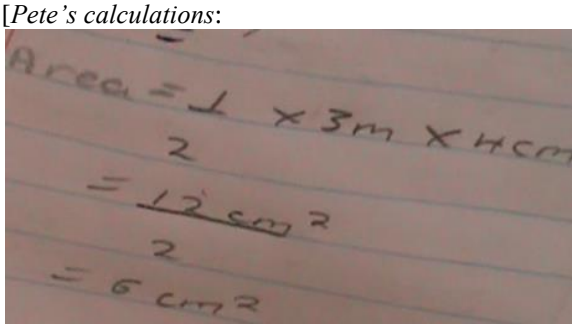
In a similar manner, in Teacher 2's class, learners were given a problem to work on as a way to practise or show understanding of the taught concepts. The problem demanded calculation of Area of a tringle of base 6m and height 4m. Two learners, Pete and Mpho, had a discussion as they worked on the problem.



In their discussion, they correctly remembered the formula for Area of a triangle and correctly wrote it down. However, they displayed a lack of understanding of the concept of Area of a triangle when they had a problem identifying the appropriate dimensions of the triangle to substitute into the formula. At some point they decided to take half of the base, 6cm, to make

it the base. This confusion was brought by the fact that the example used during the teacher's presentation was a right-angled triangle, so it was easy to identify the base and the height. The two then proceeded by using 3cm as base and height as 4cm and substituted them in the formula and proceeded with their discussion on the multiplication procedure. This however got them an incorrect answer according to the given diagram (see the extract below).

24: Mpho: Yes, it's equal. 6 cm, meaning the base is 6 cm, right? Here he has divided it, right? To make that right-angle.
25: Pete: Yes. 90 degrees
26: Mpho: Yes. So what do we do? Are we gonna divide it by 2?
27: Pete: Maybe let's say 3… let's break this into 2 [*Pete points at the base*]
28: Mpho: Okay, and then?
29: Pete: And then we put it here, Half times 3!
30: Mpho: Okay
31: Pete: Times 4, right? And then the answer…
32: Mpho: 1 times 3 equals 3, times 4…
33: Pete: Twelve
34: Mpho: Divided by 2
[*Pete's calculations*:



Pete and Mpho's discussion indicated that they could follow how the 'taught' formula was to be used and which sides to substitute into the formula as presented in the teacher's examples. Their confusion – due to using a different triangle – indicated that cognitively they were engaged through a superficial strategy where they depended on the memory of what was presented as an example. None of the two partners attempted to mathematically reason or probe each other for such reasoning for choosing to use half of 6 as the base. The only reason for their choice was because the teacher did so in his examples. This thus indicated the ritual routines performed to adhere to their teacher's procedure adopted from the previously given examples. Their ritual routines were further attested by their disobjectified discourse, where the talk was personalised and processual and thus lacked structure.

In conclusion, the two teachers similarly presented their lessons involving direct instructional approach (backed and substantiated by their interview responses), and their teaching routines were rituals. Their teaching actions mostly engaged learners superficially by memorisation and rote use of demonstrated formulae and procedures. This however occurred differently in each

teacher's class. Their differences were more visible where Teacher 1 involved some actions of active instructional approach which were not observed in Teacher 2's class. Since each teacher introduced the formula of triangle ritually as half of Area of rectangle, learners in their classes showed lack of understanding of the concept and adhered to the procedure of dividing Area by two as a ritual (a rule/method to stick to always). The learners therefore were ritual performers who showed other incompetences such as computational inaccuracy, and disobjectified discourse. Thus, the classroom environments created by these teachers could be concluded to have not availed enough opportunities for learners to be autonomous in their mathematical knowledge development.

5.2 Ultimate changes resulting from the Pilot

In addition to the modifications done to improve the data collection processes and tools (elimination of observation tool; reduction of number of cameras to two; improvement of interview questions; and improvement of problem-set items), the pilot revealed the need to make changes in the conceptual framework thus inducing changes in other parts of the study such as research questions and analytical tools. The analytical framework had some methodological inconsistencies. That is, the use of Reeve's types of learner engagements seemed irrelevant to the qualitative analysis that was to be performed in the main study. This was due to the fact that the original development of the types of engagements was achieved through a quantitative analysis of a questionnaire survey. It was also difficult to address behavioural engagement since it was not part of the focus in the study.

The aspect of learner engagements was therefore discarded from the analytical framework and related codes removed from the codes table. As a result of this change, a more relevant theory, Pedagogical link-making and communicative approach (Scott *et al*., 2011; Mortimer & Scott, 2003), was incorporated. Due to the change in framework, a research question relating to learners' engagements was changed to one relating to classroom interactions. A new set of data codes was developed from this improved framework for the purpose of the main study analysis. The detailed elaboration of the development of these data codes is presented in Section 4.5.1, while the data codes are presented in **Appendix J**.

5.3 Conclusions on the Pilot Study

The purpose of the Pilot study was to test the usability of the data collection instruments with the purpose of improving them and restructure the research questions wherever necessary. As

a result, research questions were restructured to attain their precision for the main study. The teachers' interview questions were restructured by removing some questions and follow-up questions to attain a total of 12 questions. An attempt was made to use an observation tool with predetermined codes, but the tool was found less useful since the study was explorative hence the tool was limiting and thus was eliminated.

The study also recorded the learners' group discussions. For this purpose, I had a problem-set prepared for such group discussions. However, one of the teachers showed discomfort with using such problem-set and therefore chose to use activities from the learners' textbook. This therefore challenged the usability of the problem-set. In addition to this, some learners in their groups showed some difficulty in using the polygon in the problem-set, hence the labelling and the orientation of the polygon were readjusted to make it easier to use. The wording of the stem of the problem was adjusted to make the problems easier to interpret.

In addition to restructuring the research questions and the data collection instruments, the Pilot study was used to test the usability of the analytical tool. To do this, the data from the two teachers' classes was selectively analysed. The analysis revealed similarities and differences between the two teachers in terms of instructional approaches, routines and discourses, and learners' competences in terms of conceptual understanding and computational accuracy, routines and discourses objectification. As a result of this analysis, major changes were done on the frameworks of the study hence other sections of the study were affected.

5.4 Overview and Introduction of the Data presentation and analysis Chapters

In the following Chapters (6 to 9), I provide the presentation and analysis of the data gathered from each of the four teachers and their learners for the main study. Each of the four chapters shows the presentation and analysis of data from a respective teacher's class obtained through whole-class observations, including selected learners' group discussions, and teachers' semi-structured interviews. Each sub-section in each chapter represents an episode in which the respective teacher was teaching concepts of Perimeter and Area, and in which group(s) of learners were working on the problem-set prepared and distributed to them to stimulate their discussion. One of the sections in each chapter shows the data analysis for the teacher's responses to the interview questions, while the last section shows the consolidation and comparison of the observations data against the interview data, and the conclusive description of each teacher's classroom environment. The selection and presentation of the episodes relied

on the relevance of the observed and/or uttered actions, communication and writings of the teacher and/or learners, to the research questions guiding the study.

In each episode, I present the observed teacher's actions and their interaction with learners during the teaching-learning process, including the communication and writings. Pieces of these actions for each episode are placed as extracts to provide evidence. Each extract includes verbatim transcripts of teacher-learner and learner-learner dialogue and images of what the teacher wrote on the board and/or what the learners wrote in their exercise books.

Chapter 6: Data Presentation and Analysis 1– The Case of Nthabi's Class

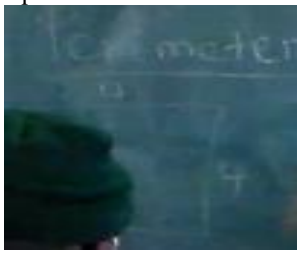
6.1. Nthabi's Instructional Practices

This section presents teacher Nthabi's instructional practices as observed from her classroom teaching. These are presented in five episodes which are titled according to the teaching activity observed. The classroom environment created and monitored by the teacher is described by the diversity (or lack thereof) of instructional approaches, types of discourses and routines, and interactions involved in teaching the concept. In each episode, the data is first presented as extracts from classroom discussions, as it sequentially occurred in each lesson, followed by the analysis.

6.1.1. (Episode 1; Lesson 1) Teaching Perimeter – from definition to computational procedure

Nthabi's lesson began with learners greeting the teacher and reciting the day's date and the teacher ordering them to have their seats. The teacher then introduced the topic of discussion by asking learners if they remembered the 'pre-told' topic of discussion for the lesson. The teacher then probed learners to define the concept of Perimeter and to suggest the computational procedure to use to find it for any given shape. She then went on to give an example, with a square, and led learners on how to go through the computational procedure as she worked it out (see the extract below).

01: T1: What did I say we're going to talk about today? Yes!
02: Learner 1: Perimeter and Area.
03: T1: We're going to talk about Perimeter and Area. Somebody define Perimeter for us. Yes!
04: Learner 2: Perimeter is the distance outside the shape.
05: T1: She says it's the distance around a shape; is that so?
06: Learners: Yes, teacher
07: T1: Okay if we have a circle and we want to calculate its Perimeter how are we going to find it? Yes!
08: Learner 3: On its edges.
09: T1: On its edges? Does a circle have edges people? What about a square? How do we find Perimeter of a square? [*Learners remain silent. T1 turns to the board and draws square*] Suppose we have a square like this. Here it's 4cm, 4cm, 4cm and 4cm.



10: T1: How do we calculate the distance around this shape? Yes!
11: Learner 4: We are going to add all the numbers around the shape.

12: T1: Okay that is we are going to add the numbers or the size of the length along the sides. That is, we have 4
plus 4 plus 4, plus 4, right? How much is it?
13: Learner 6: Sixteen.

The learners showed that they completed their homework by looking into the definition of the concept of Perimeter and how it is calculated or computed. This is reflected in their ability to correctly define Perimeter and narrate its computational procedure. Though they were not accurate in the use of words, (numbers instead of sides or measurements) learners showed that they had some knowledge about how to calculate the Perimeter of a given 2-Dimensional shape. Though the questioning did not demand any problem-solving skill, learners showed some level of competence. For this introductory part of the lesson, Nthabi's teaching involved a series of questions for the learners. These questions showed that the teacher wanted to actively engage her learners in their learning process. Most of the questions demanded learners' thinking or suggestions on the definition and computational procedure for the concept of Perimeter.

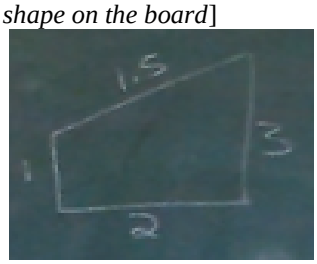
In the above extract, Teacher Nthabi began her lesson by probing learners to suggest a definition for the concept of Perimeter. Though this was a weak link, Nthabi proceeded by making a link between the definition and computational procedure of adding all sides of a polygon. The link is made even more explicit by the teacher's question '*How do we calculate the distance around this shape?'* '*How do you find the Perimeter of this one? You want to find the distance around this shape, how do we find it?*' (Line 10). The re-mentioning of the definition of Perimeter in the form of a question demanding learners' suggestion of a computational procedure was a clear way for the teacher to guide learners in making such a link between the definition and the computational procedure. Since the learners were given an opportunity to take part in the conversation through a probe on finding that procedure, this communication followed a dialogic/interactive communicative approach. Thus the teacher led a process of link-making to support knowledge building: making links between modes of representation (definition and computational procedure of Perimeter), through a dialogic/interactive communicative approach.

At this part of the lesson, Nthabi's teaching activities involved routines of a ritual nature. Learners were given a chance to come up with some definition and computational procedure (without the teacher telling). However, the teacher's questioning only demanded learners to

narrate how the computational procedure could be performed without a thorough probe into the conditions under which it could be performed. The ritual nature of Nthabi's teaching was further attested by the disobjectified nature of her talk with the learners as they discussed the computational procedure step-by-step. The procedure was discussed as a process done by the group to get the group's final answer (that is, processual and personalised discourse). This disobjectified (processual and personalised) discourse was signified by the teacher's and learners' use of personalist statements (use of 'we') which narrate the process of addition (see lines 10, 11, and 12).

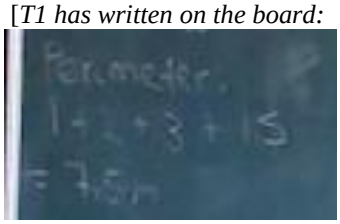
The teacher continued with the same question-answer interaction with learners while working on the next example, an irregular quadrilateral (drawn on the board). In this activity, learners stated the definition and the computational procedure as the teacher probed. However, the learners were not certain which sides of the drawn shape would be added to calculate the Perimeter of the shape. The teacher tried to leave it to learners to decide which sides to use but they failed to provide accurate answers. As a result, the teacher had to tell and lead them through the process of identifying the sides to use, and the computational procedure in using those sides.

14: T1: Okay now suppose we have another different shape maybe. [*T1 draws another shape on the board*]



15: T1: How do you find the Perimeter of this one? You want to find the distance around this shape, how do we find it? Yes!
16: Learner 7: Teacher I was going to say we add the numbers.
17: T1: We add the numbers? Which numbers are we adding here? We want the distance around the shape, which ones are we going to add? [*T1 writes "Perimeter"*] Right someone else, we said we are adding the sides right?
18: Learners: Yes, teacher
19: T1: Which sides do we have here? We have which one, which one and which one? Yes!
20: Learner 8: I think we have one, two, three
21: T1: One, two, three and?
Learners: 1.5
T1: One point five. We are adding all the sides; so we are going to have 1 plus 2 plus 3 plus 1.5. Okay how much is 1 plus 2?
Learners: It's 3
T1: It's 3, plus 3?
Learners: it's 6
T1: 6, and then 6 plus 1.5 is?
Learners: 7.5
T: It's 7.5, that means the Perimeter of this shape it's 7.5

[*T1 has written on the board:*



In the above extract, the active nature of this part of the lesson (displayed in the prior extract) was however soon adjusted into some actions of direct instructional approach. These are actions such as: teacher repeating-and-expanding, correcting and further elaborating on learners' responses to make final narratives for clarity; giving further examples and repeatedly reminding learners the definition and computational procedure in order for them to be able to work on the example and come up with correct responses; didactically working through the examples while guiding learners with some leading and confirmatory questions throughout the computation process to get the correct answer; and telling learners how to determine the units of the final result.

In this extract, Nthabi attempted making a link between the concept of *Length* and the concept of *Perimeter* through their units of measure. Following a teacher-led probe on the computational process (in calculating the Perimeter of the given shape in the example) and satisfied with the final answer, Nthabi further explained how the units of Length become the units of Perimeter . Since at this point only the teacher was involved in the talk, this was a non-interactive/authoritative communicative approach.

Teacher Nthabi's teaching in this extract involved her question-answer interaction with the learners as she tried to guide learners in how to use the add-all-sides procedure to find the Perimeter of the polygon given as an example. In this talk, the teacher's focus was on the learners' ability to identify the sides of the shape which form the Perimeter hence to be added for the procedure. As a result, the questioning demanded learners to mention the sides and the procedure to use without elaboration on why such sides were appropriate for the procedure. The learners were also not offered an opportunity to work on the example on their own. The teacher's routines therefore were rituals aimed at guiding learners to identify such sides and substituting correctly in the procedure. This ritual was also observed in the teacher's use of disobjectified discourse. That is, she talked of Perimeter as the process of identifying sides of the polygon and adding those sides, hence processual discourse, and using personal pronouns

in that talk, hence personalised discourse (see line 21: *We are adding all the sides; so we are going to have 1 plus 2 plus 3 plus 1.5…*).

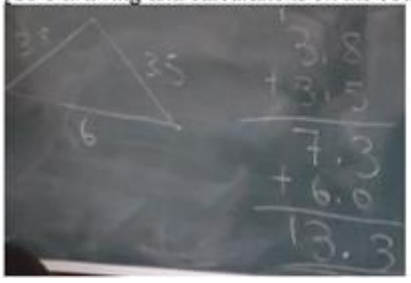
In summary, in this episode, very few incidents showed teacher Nthabi's attempt to use an active instructional approach. Even so, there were more incidents in which she used actions of direct instructional approach. Two pedagogical links were made and two communicative approaches were observed while the teacher provided explanations and led some discussions on the concept of Perimeter. These were link-making: to support knowledge building - making links between modes of representation (definition and computational procedure of Perimeter); to support knowledge building - making link between scientific concepts (Concept of Length and Concept of Perimeter through their units of measure); dialogic/interactive communicative approach, and non-interactive/authoritative communicative approach. All the observed teaching actions in this episode featured ritual routines which were intertwined with mostly colloquial and disobjectified discourse.

6.1.2. (Episode 2; Lesson 1) The Working-Example Activity on Perimeter

In addition to examples worked out in the introduction, Nthabi provided learners with more, including those copied from the learners' textbook. Throughout this worked-examples session, the teacher worked out the first example didactically (on the classroom board) while reminding learners the computational procedure and leading them with confirmatory and leading questions through a computational process (shown in the extract below).

22: T1: We have a shape like this, do we all see it?... I'm going to do the first example so that we all see it okay?
23: Learners: Yes, teacher
24: T1: We said that when we calculate the Perimeter of a shape we are going to add all the sides, right? That means in order to find the Perimeter of this shape we are going to have 3.8 plus 3.5 right? …now 8 plus 5 is?
25: learner 8: Thirteen
26: T1: Thirteen, we put 3 we carry 1. Three plus three is?
27: **Learner:** Six] 6, then plus 1?
27: Learners: Seven
28: T1: 7, then we put 7 and we remember the decimal right?
29: Learners: Yes teacher
30: T1: Okay now we are going to add six also… okay because 6 is a whole number we have to write it in a decimal form and we are going to write it as 6.0, okay?
Learners: Yes, teacher Now we have 3 plus 0. How much is 3 plus 0?
31: learner 9: Three
32: T1: It's three. Now how much is 7 plus 6?
33: learner 10: Thirteen

[T1's drawing and calculations on the board:



> **34: T1**: It's thirteen, and then we remember to keep the place value with a decimal…Now we say that the Perimeter of this shape is 13.3, it is like that, isn't it?

Nthabi's act of providing the worked examples as a way of demonstrating to learners how the taught procedure works, indicated her preference for direct and teacher-guided approach. This was further indicated by her direct guide with leading and confirmatory questions as she didactically worked through the computational process on the addition of decimals. Throughout this teacher-worked-example session, learners were only engaged through leading and confirmatory questions (for example, *right?*) to which they had to provide a '*yes teacher*' response or provide an answer to addition of the uttered digits.

The actions displayed in the above extract showed the teacher's didactic work on the example to demonstrate to learners how to identify the sides of the polygon to use for calculation of Perimeter and the arithmetic process thereof. Therefore, there were no pedagogical links made either by the teacher herself or by the teacher with the learners. However, the teacher posed questions to the learners as she was procedurally working on the example and learners provided responses which were mostly a 'yes teacher' response and uttered numbers as answers to the addition process that was executed by the teacher. This teacher-learners talk was therefore interactive since not only the teacher was talking. However, there was no dialogue between the teacher and learners since they only talked not to raise their own opinions or come up with new ideas but to respond to the teacher's confirmatory questions as she worked out on the example. This therefore indicated that the teacher mostly used an interactive/authoritative communicative approach.

The teacher's questions to the learners demanded only their admission of her explanations and workings on the board and giving answers to the teacher's hinted calculations. There was no teacher's probe to the learners for new ideas and reasoning for whatever responses they provided. Therefore, the teacher and learner routines on this part of the lesson were rituals. The teacher-led talk was mostly personalised and processual since the teacher explained and posed questions on Perimeter as a process of adding the digits around the polygon and performed as the teacher's and learner's own action, hence the disobjectified colloquial discourse.

In this worked-example activity, the next step was to invite a couple of learners (Pali and Tsepo) to walk to the front and work out the next set of examples, from the textbook, on the classroom board while asking the rest of the class if they had questions on the teacher's worked

example and concept of Perimeter in general. As they worked on the given activity, Pali and Tsepo first copied the diagrams from the textbook and started calculating (this was exactly how their teacher did it in the first worked-example, including the way each learner presented the calculations). During this process, the rest of the class remained silent and inactive as they watched and waited for Pali and Tsepo to finish their workings on the board.

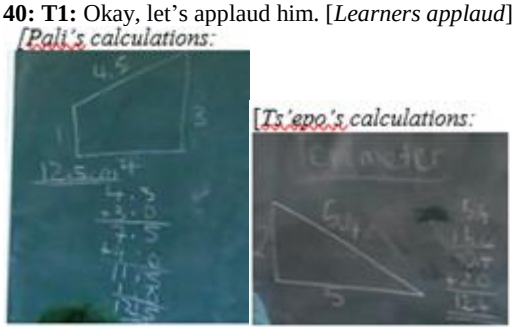
> **34: T1:** Okay can I see somebody who is going to do number (c) inside the textbook. Somebody to come and write number (c) on the board…Yes! Okay as she is doing number (c) on the board we need someone else to come and do number (g)…what is the Perimeter of the shape in question number (g)? You want to do it on the board? Okay come and do it. Do we have any questions people? Any questions about finding the Perimeter of the shape? [**A few learners**: No teacher] Are you sure?... Okay
> [*Pali continues to work on question (c) on the right part of the board and Tsepo works on question (g) on the left side. The class remains silent as the two learners proceed with their calculations. Tsepo copies from the textbook to the board a shape and labels its dimensions before writing his calculations – just like the teacher did*]

The teacher's act of inviting two learners to perform the calculation of Perimeter on the classroom board seemed like a way to engage learners actively in their learning. However, this act only engaged the two performers and left the rest of the class inactive since they silently and inactively watched and waited for the two to complete their workings on the board. Further, the two activated performers were tasked with working on the given example as a way of a drill and practice on the demonstrated computational procedure. Therefore, their actions were a rote performance on the demonstrated procedure to practise and perfect their performance on such procedure, hence their routines were rituals.

As each of the two performers completed their workings on the board, the teacher tried to activate the rest of the class by asking them if the two performers' workings and final answers were correct. To confirm if the computations were correct, Nthabi proceeded by leading the class by confirmatory questions through the computation process. Satisfied that Pali and Tsepo's computations were correct, teacher Nthabi summarised the process by telling the class that that is how the Perimeter of any shape could be calculated (shown on the extract below).

> **35: T1 (to Pali)**: Are you done? [*Pali nods*] is it correct people? [*Learners do not respond*] Is she doing it correctly? [*Learners are still silent.* No!? Let us look at it together people, is this answer correct?
> **36: T1:** Eh…we have 5 plus 0, the answer is? [**Learners**: Five] 4 plus 3? [**Learners**: Seven] Now we add another side which is 4, and now we say 5 plus 0 is? [**Learners**: Five] 7 plus 4 is? [**Learners**: Eleven] we add another side here because we left this 1. Five plus 0? [**Learners**: Five] 1 plus 1? [**Learners**: Two] And then we have this 1 here, the answer is 12.5. The answer is correct, let's applaud her. [*Learners applaud*]
> **37: T1**: So this is how we calculate the Perimeter of a shape. We are adding the side right? [**Learners** in chorus: yes, teacher]
> **38: T1:** Okay if… the shape has four sides it means we are going to add four numbers right? [**Learners**: Yes, teacher]
> **39: T1 (to Ts'epo):** Are you done? Okay, thank you. So…is this answer correct? We have 5.4 plus 5.0, he says the answer is 10.4. We add 2 and then we have 12.4. Is it correct? [**Learners**: Yes, teacher]

40: T1: Okay, let's applaud him. [*Learners applaud*]



For this part of the lesson, Nthabi tried to make the lesson to be active by involving learners in working on the problems from the textbook, on the classroom board. However, this activity operationalised only the pair of learners involved in the calculations while the rest of the class was passively watching the two. Though the class was given a chance to proof-check the accuracy of the Pali's and Tsepo's calculations, the activity took a direct instructional turn when the teacher didactically worked through the proof-check process while only guiding learners with leading and confirmatory questions.

This part of the lesson was run by a drilling exercise where two learners were selected to illustrate to the class how a demonstrated computational procedure could be performed, as a way of drilling and practising them. As a result, no clear link-making was observed either by the teacher or the learners. However, one weak link between the properties of a polygon and the computational procedure was observed in teacher Nthabi's explanation which followed the two learners' writings on the board. Here the teacher tried to explain and demonstrate to the learners that in order to come up with a correct answer for the Perimeter of any polygon, they had to count the number of sides of the polygon and then add them all together. This way the teacher was making links between two scientific concepts (properties of a polygon and computational procedure for Perimeter).

The teacher was the only one doing the talking (no exchange of ideas) since the learners merely participated by providing a confirmatory response '*yes teacher*' and answers to the computational process while probed through confirmatory questions by the teacher. The talk therefore reflected a non-interactive/authoritative communicative approach.

Besides being dominated by actions of a direct instructional approach, Nthabi's teaching routines on this activity were rituals. The purpose of the learner-worked-example activity was for learners to conform to how the teacher did the first example (copying and drawing the

shape; working and presenting the computations). This was further attested by the confirmatory activity where the class was asked if the work of the two selected learners was correct in terms of the procedure and the answer accuracy (and teacher-led computations), and thus striving for uniformity of the computational process. Furthermore, the teacher-learner discourse on the arithmetic processes executed was more personalised and mostly centred on the process followed to obtain the correct answers, hence disobjectified. This therefore indicated further that Nthabi's classroom routines were more of a ritual nature.

In summary, teacher Nthabi used an active instructional approach partially in this part of the lesson since only two learners were actively involved in the board work while the rest of the class was passive. Part of the activities showed a direct instructional approach. These included teacher's re-work on the problem to proof-check the performers' work. Though the activity mostly involved learners' board-working, the teacher attempted some explanation which involved some weak link-making to support knowledge building – making links between scientific concepts (properties of polygon and computational procedure for Perimeter). Throughout this activity, the teacher did most of the talking which included posing confirmatory questions to the learners over the arithmetic process to confirm the answers. In this talk, the learners did not do much of the back-talking hence the teacher used a non-interactive/authoritative communicative approach. The instructional environment in this part of the lesson involved disobjectified discourses and ritual routines.

6.1.3 (Episode 3; Lesson 1) The learners' drilling exercise on Perimeter of simple equilateral polygons and parallelogram

In addition to the learners' board demonstrations on how to perform the computational procedure for Perimeter of trapezium and triangles, Nthabi further led a presentation on Perimeter of squares, equilateral triangle and parallelogram. The teacher's presentation on the Perimeter of a square and equilateral triangle proved to be her attempt to show the learners that for any equilateral polygon, the add-all-sides procedure alternatively becomes a multiplication operation in which the length of one side is multiplied by the number of sides of that polygon. For this presentation, the teacher began by leading learners into a review of some properties of such polygons (equality of sides).

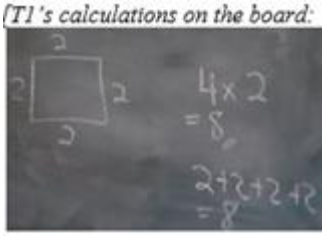
The presentation involved the teacher probing learners into a review of the add-all-sides computational procedure. The learners were asked to find the Perimeter of a square of side '2',

which they correctly provided as ‘eight’. The teacher then enlightened them that it was the same as multiplying the side ‘2’ by 4 (number of sides), and didactically provided the calculation process. Throughout this process, the learners were asked a series of leading and confirmatory questions, hence most of their responses were answers to addition and multiplication operations and a ‘*yes teacher*’ response (shown in the following extract).

41: T1: …for a shape like a square, square has all the sides equal right?
42: Learners: Yes, teacher
43: T1: That means if we have… [*T1 draws a square on the board*] suppose this is 2 centimetres, 2 and 2 and 2.

How much is the Perimeter of this shape? [**Learner 1**: Eight]
44: T1: It’s going to be eight. How did she find eight? Yes!
45: Learner 2: She added 2 plus 2 plus 2 plus 2
46: T1: Okay. We added how many 2s? [**Learners**: Four]so the answer is still the same as when you say this shape has four sides and those four sides each has length of 2. That is, the answer when you multiply 4 by 2 we get? [**Learners**: Eight] So now in order to find the Perimeter if the sides are equal, you take the number of sides times the side right? [**Learners**: yes, teacher] so now, the sides of a square are equal, they are four. That says you are going to take four and multiply it by the length of just one side. You still get the same answer right? ...This is still the same as when we add 2 plus 2 plus 2 plus 2, the answer is still eight right? [**Learners** in chorus: yes, teacher] What I’m saying is that when the shape has equal sides, you just count how many sides you have then
multiply by one side, right? [**Learners**: Yes, teacher]

(T1’s calculations on the board:



For this part of the lesson, teacher Nthabi provided her class with an example to introduce the multiply-by-number-of-sides procedure and demonstrate didactically how it worked on different types of equilateral shapes and how it compared to previously demonstrated add-all-sides procedure. Learners only got involved in the discussion by providing answers to the teacher’s leading and confirmatory questions as she worked out the Perimeter of the shape in her examples. Teacher Nthabi therefore was observed to have been using direct and authoritative instructional approach.

In the above extract, Nthabi provided explanations on how the add-all-sides procedure in the calculation of Perimeter of a square (a regular polygon) connects to or becomes a multiply-one-side-by-number-of-sides procedure (see line 46). In this way, the teacher made a link between modes of representation, which in this case are the two computational procedures. During the conversation which led to the teacher’s link-making explanation, the learners were

involved in the conversation by direct questions which demanded them to narrate the procedure used to find the final answer and the final answer itself, hence involving interactive/authoritative communicative approach.

However, during the link-making explanation between the two computational procedures, the teacher was mostly the one doing the talking while the learners remained passive and only talked when providing a '*yes teacher'* response to teacher's '*right?*' lead or otherwise provided an answer to an addition process led by the teacher (line 46). This therefore indicates that the teacher used a non-interactive/authoritative communicative approach to make such a link, while she used an interactive/authoritative communicative approach on other parts of the conversation that led to the link-making explanation.

The teacher's routine of introducing and leading learners through the multiplication computational procedure (by example) as an alternative for addition of all sides was her ritual to make learners memorise both procedures. This was also to enable them to master each version of the procedure separately whenever they work on a Perimeter of a regular polygon. The ritual nature of the teaching activities was further indicated by processual and personalised (hence disobjectified) discourses as the teacher posed questions and provided explanations.

The teacher's presentation on Perimeter of a square, as a product of size of one side and number of sides, was immediately followed by learners' task on calculating the Perimeter of an equilateral triangle. Learners therefore simply and correctly found the answer by applying the multiplication operation as explained and demonstrated by the teacher. A similar process was followed by teacher Nthabi to introduce the learners to calculating the Perimeter of a parallelogram (that is, review of properties; locating sides to use; computing the Perimeter while leading with confirmatory questions) (shown in the following extract).

47: T1: Let's make an example; if we have a triangle, [*T1 draws a triangle on the board*] that has all the sides equal and we are told that this side is 3cm, how much is the Perimeter of this? Yes! [*T1 selects a learner to answer*]
48: learner 12: Nine
49: T1: It's nine, how did you find nine?
50: learner 12: I multiplied my triangle.
51: T1: Aha! Because this shape has three sides… If we don't have questions, then let's have an exercise and see how we do on it. In the same page that you have, let us do number (b) on a parallelogram [*draws the parallelogram on the board*] ... is this side given?

52: Learners: No teacher.

53: T1: What about this one? [**Learners**: Yes, teacher] how much is it?
[**Learners**: four] it's 4, what about this one? [**Learners**: 2.4]
Okay. Now we know that on a parallelogram this side is equals to this side right? [*T1 points at the two longer sides*] [**Learners**: yes, teacher] …And this means
how much is this side? [**Learners**: four] It's 4. And this side is also equal
to the other side [*T1 points at the two shorter sides*] how much is this one? [**Learner**s: 2.4] it's 2.4.

[*T1's diagram;*



The teacher's act of providing one more example with an equilateral triangle was a way to further demonstrate to the learners how the procedure works. This act could be seen as an element of direct instructional approach. However, the teacher gave learners an opportunity to work on the problem and provide an answer as a way of drilling and perfecting their memory of the procedure, hence this was an act of active instructional approach. This active instructional approach was attested further by the teacher's question (*…, how did you find nine?*) which demanded the learner to narrate the procedure used to obtain such an answer. On introducing the procedure for computing the perimeter of a parallelogram, the teacher attempted to demonstrate how the procedure could be performed for different types of polygons. The presentation followed a direct instructional approach since the teacher posed leading questions which were meant to remind learners about the equal-parallel sides property of a parallelogram which would guide them on how to apply the procedure in calculating its Perimeter.

In this extract, no link-making explanation was provided by the teacher or learners. The teacher-learner talk in the beginning of the extract (lines 47 to 51) shows the exchange of words between the teacher and one learner, hence there was a teacher-learner interaction. The learner was even probed to provide a procedure used to find the answer, hence there was a dialogue, thus the teacher involved interactive/dialogic communicative approach. In introducing the Perimeter of a parallelogram, the teacher posed confirmatory and leading questions to lead a review on parallel-equal sides property of a parallelogram, which made the learners to take part in the review process by providing answers accordingly. The teacher-learner talk therefore was interactive yet teacher-authoritative since learners were not given the opportunity to come up

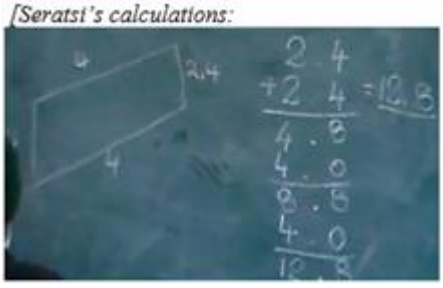
with new ideas or suggestions hence limiting the dialogue. At this point, the teacher therefore used interactive/authoritative communicative approach.

While leading the discussions in the above extract, the teacher's introduction of a further example or activity on Perimeter of equilateral triangle was a further step into her teaching ritual routine which was executed to allow learners' memorisation and perfection of the use of the procedure. The ritual was also observed in the teacher's lead on the review of sides of a parallelogram since the leading questions posed referred to the well labelled parallelogram drawn on the board. Though the talk was about the properties of a parallelogram which involved learners' utterance of number words, the overall talk did not address any discussion on a mathematical concept, hence the discourse was colloquial.

Similar to ***Episode 2***, for further example (on drawn parallelogram) and practice on the demonstrated computational procedure, learners were invited to demonstrate their computations on the board, and Seratsi was selected for the task. As she worked on the board, the rest of the class was ordered to carry on with the exercise from the textbook, writing in their exercise-books while they discussed in groups. As Seratsi completed her work on the board, the teacher consulted the class to check the accuracy of the answer (shown in the extract below).

54: T1: Now can someone come and find the Perimeter of this shape? Yes, Seratsi! As she is doing it on the board I want us to do number (e) in our books. Find the Perimeter of the parallelogram [*Seratsi continues working*] …Can we have somebody else to come and do number (e) for us? Yes! [*T1 selects another learner, Thabo*] So no questions on this one? Is it clear?
55: Learners: Yes, teacher okay then we are going to do more exercises. Are you done? [*T1 asks Seratsi*] Okay… she says the answer is 12.8, is that so? Is it correct?
56: Learners: Yes, teacher
57: T1: Okay if it's correct let's applaud her. [*Learners applaud*] Let's do some more exercise from your textbook, in our groups…

[Seratsi's calculations:



The teacher's act of inviting one learner to demonstrate his workings on the board while ordering the class to perform their own workings in their books indicated her intent to engage

all learners actively. This active act was further observed when she ordered the class to carry out some further exercise from the textbook.

The teacher-learner talk in this section of the lesson involved a non-interactive/authoritative communicative approach since the teacher was the one doing the talking while learners only produced a 'yes teacher' response. There were no link-making that took place since the teacher was enquiring if the workings on the board were correct or if the learners had further questions hence giving more exercises to work on. The teacher's repetitive invitation of learners to demonstrate their workings on the board appeared to be a ritual routine meant to allow learners to further practice and perfect the rote use of the taught procedure and allow them uniformity in problem-solving. This communication involved very few mathematics words since it was mostly about the teacher's command for learners, hence the discourse could be regarded as totally colloquial an disobjectified.

Generally, in this episode, Nthabi's teaching involved, in most cases, a direct instructional approach. It included actions such as didactically explaining and working on the example to show how the multiplication operation became an alternative to the addition of sides operation. The learners were mostly involved in answering the teacher's leading and confirmatory questions while she worked on the example. A similar approach was used by the teacher when didactically leading learners in identifying the sides of the parallelogram to use for computation of its Perimeter.

Overall, only one link was made, the link-making to support knowledge building - making links between modes of representation (the add-all-sides procedure and multiply-by-number-of-sides procedure for Perimeter of regular polygon) and two communicative approaches were observed at different parts of the interactions, the interactive/authoritative communicative approach**,** and non-interactive/authoritative communicative approach.

Most of the teaching-learning routines observed in this episode were rituals. This is due to the fact that most of the presentations were executed by the teacher to show learners how the add-all-sides procedure for Perimeter connects or derives into a multiply-by-number of sides for a regular polygon. These routines were also observed in actions where the teacher involved learners through leading and confirmatory questions throughout the computational processes as she worked on examples on Perimeter of a square, trapezium and others. The ritual was

further instilled by giving learners a task on an equilateral triangle as a way to make them practise the procedure, and show if they had followed the example well. The working on the board task for learners also added to the ritual nature of Nthabi's teaching since the learners were tasked with demonstrating their workings to others in order to show that they had memorised the procedure and so that the rest of the class could see how it had to be done so that they could do the same. Each of the learners who demonstrated their workings on the board never (or were never probed to) explained to the class how and why they did it the way they did.

The disobjectified nature of Nthabi's discourse, in most parts of this lesson, further proved the ritual nature of her teaching approach. For instance, after ordering learners to work in groups, Nthabi went from group to group monitoring their progress and the accuracy of their computations. Her talk in those discussions was personalised and mostly about the arithmetic processes of computations, and she finally ordered her learners to continue with their workings like she did and explained. Example:

> **T1**: Which one is the final answer? You added 12cm plus 6cm here, right? Then you added 4 and 3, right? Then you added 1.5 and 3, it's here. Then this one …when you add them try to add them altogether, like as you start with this one; it will be 12cm plus 6cm right? And then 2 plus 6 is 8, then we have 1. We have already added these two, right? We are now on the last one here, because when you add them like this you will end up forgetting the other results. Now you underline this; now you have 8 plus 4? It's 12, we put 2 we carry 1, 1 plus 1? Aha! We have already added this one? Now we come to this one. Continue like this. [*T1 gives back the group's book to Member 1 and goes to group D*]

6.1.4 (Episode 4; Lesson 2) Area as a Unique Concept for Specific Types of Shapes – Disconnected Computational Procedures/Formulae

Nthabi's lesson on the concept of Area began with her probe on learners' thinking about the definition of Area. Following the probe, one learner defined Area as *"space inside the boundary of a shape"*, which sounded incomplete since there was no mention of 'flat surface covered by the shape'. The teacher approved the answer by repeating it to the rest of the class. She further approved it by commanding the class to say the definition repeatedly in a chorus as a class (shown in the extract below).

> **58: T1** (to class): …What is Area?... Yes
> **59: Pali:** Space inside the boundary of a shape
> **60: T1**: Okay so... she says that Area is the amount of space that is enclosed… let's say it together then!
> **61: Learners:** Area is the amount of space inside the boundary of a shape.
> **62: T1:** Again. [*T1 moves towards the board and writes the definition of Area*]
> **63: Learners in a chorus:** Area is the amount of space inside the boundary of a shape.
> **64: T1:** Once again.
> **65: Learners:** Area is the amount of space inside the boundary of a shape.
> **66: T1:** Okay so we are saying that Area is the amount of space inside the boundary of…of a shape. *[T1 has written on the board: "– Area is the amount of space inside the boundary of a shape"]*

In the above extract, teacher Nthabi's act of probing learners to seek their thinking or knowledge of definition of Area indicated her teaching as partially involving active instructional approach. This active involvement of learners was spread throughout the classroom by teacher leading the class to recite repeatedly the mentioned definition of Area. The teacher-learner talk involved an exchange of words, especially at the beginning of the conversation. Learners were given an opportunity to take part in the dialogue by probing them for their suggestions on the definition of the concept of Area, hence interactive/dialogic communicative approach was used. The teacher's act of repeating the learner-mentioned definition, and commanding the class to recite it repeatedly, was a ritual routine aimed at drilling them to memorise the given definition.

The teacher went on to provide an example as a way to show how the definition transforms into a computational procedure or formula. The example given was the introduction of a formula for calculating Area of a square. The teacher told learners the formula *'length times width'* and probed to remind them of an equal-sides property of a square and which sides identify as length and width. This also included an explanation on how units of length (centimetres) develop into units of Area. The discussion went further with the teacher writing the calculations on the board, as demonstration of how the formula works, while guiding learners with leading and confirmatory questions throughout the arithmetic process (see the extract below).

67: T1: Now if we have a shape like a square, we said a square has all equal sides, right?
68: Learners in a chorus: Yes, teacher
69: T1: Okay this means we are multiplying how many centimetres? How many are they?
70: Learners: Two
71: T1: They are two, therefore we have centimetre squared. The units of Area have that squared because we are multiplying two quantities okay?
72: Learners in a chorus: Yes, teacher.
73: T1: Is it clear?
74: Learners in a chorus: Yes, teacher.
75: T1: Okay this is how we calculate the Area of a square, it's length times width, right?
76: Learners: Yes, teacher

[T1's calculations on the board:



In this part of the lesson, the teacher used a direct instructional approach which was signified by directly telling learners the formula for calculation of Area of a square, providing a worked example, and reciting how the units of length, centimetres, derive into units of Area, square centimetres. These actions also indicated the teacher's use of ritual routines aimed at introducing the formula for Area of a square and its units. This is further attested by lack of mathematical reasoning and derivation of the formula and how such formula relates to the definition that had just been discussed.

In this extract, teacher Nthabi made a weak link between the definition of the concept of Area and the algebraic representation (formula), specifically of Area of a square and rectangle. She did this by writing the formula and providing an example to demonstrate how the Area of a square can be calculated soon after recitation of the definition. This therefore indicates her link-making to support knowledge building – making links between modes of representation of the concept of Area (the verbal representation, definition, and the algebraic representation, the formula). Throughout this conversation, the teacher did much of the talking especially during the link-making explanations. The learners got involved only through answering the teacher's confirmatory questions, usually with a '*yes teacher*' response. The conversation therefore lacked dialogic interaction since there was no interchange of ideas, hence making the communication follow an interactive/authoritative communicative approach.

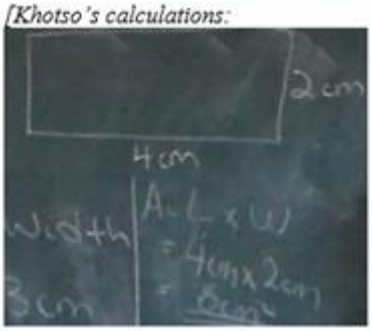
Soon after the example on Area of a square, the teacher then provided another example to show the learners that the same formula works for calculation of Area of a rectangle. For this example, Nthabi invited a learner (Khotso) to try his workings on the board. As Khotso worked on his calculations, the rest of the class and the teacher silently and inactively waited for him to finish. After Khotso had finished the calculations, the teacher asked the class if his answer was correct and the class provided the '*yes teacher*' response, hence she commanded them to applaud Khotso. She then summarised the activity by telling them to always start by writing down the formula whenever they have to calculate Area. Then she reviewed Khotso's workings didactically and told the class the correct answer and its units. This is shown in the following extract:

77: T1: The same thing applies when we find the Area of a rectangle. We are still going to do the same thing okay? [**Learners**: Yes, teacher] Let's make an example; suppose here we have 4cm and then here we have... [*T1 draws a rectangle on the board*] Can somebody come and find the Area of this rectangle? We are still using the same equation. [*T1 selects a learner, (Khotso)*] We are still using the same equation that Area is equals to length by width.

78: T1 (to Khotso): Are you done?

79: Khotso: Yes, teacher.

80: T1: Is the answer correct people? [**Learners:** Yes, teacher] Okay let's applaud him. [*Learners applaud]* …Okay now the first thing to do when you are calculating you write equation of Area and then you substitute; we have length that is 4, we have width that is 2, you multiply and you get eight, and the units are squared, right? [**Learners** in a chorus: Yes, teacher] Okay.



The teacher's act of selecting one learner to demonstrate his workings on the classroom board was a way to allow the learner to practise the demonstrated formula use and evaluate if the procedure was memorised. This therefore was an attempt to actively involve learners in their learning. However, only the demonstrator was activated while the class remained inactive. This was supplemented by the teacher's invitation of the class to comment and decide if the demonstrated procedure and answer was done correctly, hence partially using active instructional approach. Even so, this act of giving a further example on the given formula indicated the teacher's use of ritual routines. This is signified when the teacher provided a problem similar to her prior worked example hence aiming to allow learners to didactically practise and perfect the use of such formula. This was further confirmed by the teacher's conclusive explanation and re-working on Khotso's workings to approve it correct and making sure the class followed the same procedure.

In the above extract, the teacher did most of the talking in explaining that learners must follow the same procedure using the same formula as the one used in her previous example. Though learners' voices were heard, they only contributed by a '*yes teacher*' response to the teacher's confirmatory questions as she commanded, explained and provided the concluding explanation. This communication therefore followed an interactive/authoritative communicative approach.

Convinced that the learners were able to use the formula and correctly compute the Area of a rectangle and square, Nthabi introduced the formula for Area of a triangle. She did so by telling the learners that it is '*half times base times height*'. Her next step was leading learners to identify the height and base of a triangle by drawing a triangle, hence working on the example to show the learners how the formula works. Throughout this process the learners contributed

by responding to the teacher's leading questions (mostly *'yes teacher'* response) while she worked out the example on the board. The teacher then finalised her presentation by telling the learners that, that is how the Area, of square, rectangle, and triangle, is calculated. This shown in the extract below:

> **81: T1:** Now we also have another equation here, that of the Area of a triangle... we have half times base times height… triangle is a shape that has how many sides?
> **82: Learners:** 3 sides
> **83: T1**: 3 sides. Okay, now the side that is below here is the one that we call length, right? [**Learners**: Yes, teacher] or the base because it's at the bottom right? [**Learners**: Yes, teacher] Okay this is the base, what about this one?
> **84: Learners:** Height
> **85: T1:** Height, so when we find the Area of a triangle we are going to say it is half times base times height, isn't it? [**Learners:** Yes, teacher] …So if base here is 5, and this one is 4cm, now we want to find the Area of this…we will be having half times… how much is base here?
> **86**: **Learners:** 5 centimetre.
> **87: T1:** It's 5cm and then height is how much…4cm, now how much is 5 times 4?
> **88: Learners:** Twenty.
> **89: T1:** Twenty centimetre times centimetre that will be centimetre squared. How much is half times 20?
> **90: Learners:** Ten
> **91: T1:** It's ten. Okay. So the units here it's squared, we have ten centimetre squared. …Is it clear how we find the Area of the triangle? [**Learners in a chorus:** Yes, teacher] So now we can find the Area of a square, Area of a rectangle, Area of a triangle, right? [**Learners:** Yes, teacher]

The teacher's act of telling the class the new formula for Area of a triangle indicated her use of direct instructional approach. Learners were asked some leading questions in identifying the sides of the triangle to be named base and height. However, the learners' response was obvious since the teacher had already told and showed them the base or length together with its measurements. This direct instructional approach was further observed in teacher's lead while working on the example on the use of this new formula and in providing a summarising explanation on Areas of square, rectangle and triangle.

In the Commognitive perspective, these noted actions also showed the teacher's use of ritual routines since she directly provided the formula without derivation activity or any probe to allow learners to provide reasons on the appropriateness of such formula as a way of showing deeper understanding of the concept of Area. This was also upraised by the teacher's provision of an example on how to use the formula to ensure the learners' memorisation of how such formula works. The teacher's talk of the concept of Area of triangle (for example, '*when we find the Area of a triangle we are going to say it is half times base times height'*) addressed it as a processes of multiplying that learners have to always perform, hence making this discourse disobjectified. This therefore further indicated Nthabi's teaching ritual performance.

Though there was no link-making explanations or probing in the above extract, there existed communication of some level. In the teacher's talk where she provided some explanations, she posed a confirmatory question such as, '*right? Isn't it? ...is it clear?*', to which learners responded with a '*yes teacher*'. In cases where the teacher was working on the example, carrying out and explaining an arithmetic process in it, she posed leading questions demanding learners to utter a number which they consider as an answer to such arithmetic operation. This therefore showed that there was a talk between teacher and learners yet there was no exchange of ideas since learners were just giving short-led responses, hence interactive/authoritative communicative approach was used.

As her duty to monitor the learners' progress as they worked on the given exercise following the examples, Nthabi moved from group to group to mark and correct learners' work by probing, with the aim of making them see their computational mistakes (and at times telling them the correct ways or answers) (see extract below).

> **92: T1 (to the group):** When you multiply with 1, how much 1 times 2?
> **93: Member 1:** Two
> **94: T1:** How much is 3 times 5?
> **95: Member 1**: Fifteen
> **96: T1:** We put 5 we carry 1, how much is 3 times 2? [**Member 1**: Six] Plus 1? **[Member 1**: 4] …
> **97: T1:** Let's see again…. Hm? How do you multiply… … 25 by 13? We are multiplying isn't it? 1 times5?... One times six? …3 times this? You put zero…, three because you are multiplying by 3 – you carry 1, 3 times 2? [**Group:** It's six] Plus 1? [**Group**: Seven] Now you're going to add… Add! Add!

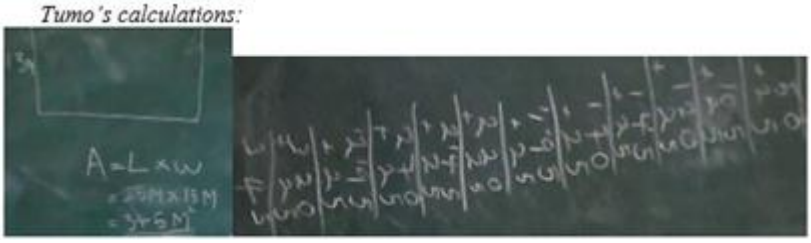
The focus of the teacher's communication with this group of learners was the correctness of the arithmetic operations they executed in using the learned formula. To show learners their mistakes, the teacher poses a series of questions to which she provided answers in some instances while allowing learners to respond to others. This could be seen as an active instructional approach act. While showing learners how to correctly execute the arithmetic process, the teacher did not probe learners for reasoning into their chosen processes which led to incorrect answers. Hence her teaching routine at this stage was a ritual intended to correct their work. Though the communication was interactive, with learners responding to the teacher's questions, it was not dialogic since the learners never raised any ideas into their answers and processes. Thus, the teacher used interactive/authoritative communicative approach.

While the rest of the class worked in their groups, one learner (Tumo) was tasked with showing his workings on the board to demonstrate usage of the given formula. When realising that Tumo

has finished working, Nthabi asked the class if his answer was correct, to which they said no. Tumo's incorrect answer therefore led to other learners giving the correct answer (see the following extract).

98: T1 (to class): Is the answer correct? [*Referring to Tumo's answer on the board*]
99: Learners: No teacher.
100: T1: What is the correct answer? How much is 25 by 13?
101: Learner1: Three twenty-five meter squared.
102: T1 (to Tumo): Three twenty-five. They say you made a minor error here.
103: T1 (to class): Is that it? How much is the correct answer people?
104: Learners in a chorus: three hundred and twenty-five meter squared.

Tumo's calculations:



In this extract, the teacher had previously tasked Tumo to display his workings on the board as a way of showing the class how best he could use the given formula and perfect the arithmetic processes involved. This was an active instructional approach directed at him as an individual. The rest of the class were activated at the later stage where they were invited to decide on the correctness of his answer, hence providing the correct one in the end. This however indicated the teacher's use of ritual routine since Tumo and the class were never given a chance to reason on the correctness or incorrectness of their answers, which indicated that the focus was on the rote use of the formula and routine performance of the arithmetic processes involved, not the concept. The learners' responses to the teacher's questions lacked dialogical interaction due to this lack of reasoning or probe for such reasoning. Thus, interactive/authoritative communicative approach was used in this conversation.

In general, in this episode, though she first probed learners to seek their thinking or prior knowledge on the definition of Area as a way to actively engage them, Nthabi's teaching soon proved to be of direct instructional approach. This is because she immediately provided learners with the formula and an example through which she worked to find the final answer. The learners' involvement in the working out of the answer for the example could not be argued to be part of active instructional approach since all the calculations and presentations were done by the teacher. The direct instructional nature of Nthabi's lesson was further observed where she, similarly, provided the formula for Area of triangle and a worked example. In both cases,

a learner was invited to present workings on the board to show that they could correctly use the given formula and accurately perform computations, as shown by the teacher in the previous example.

Though the link is not obviously identifiable, Nthabi made a link between the definition of the concept of Area and the algebraic representation (formula) of specifically Area of a square and rectangle. This she did by writing the formula and providing an example to demonstrate how the Area of a square can be calculated soon after recitation of the definition. This therefore indicates her link-making between modes of representation.

At the beginning of the conversation, the communication seemed dialogic since the teacher posed a question and a learner provided an answer. However, from that point, the communication was a learner's repeated recitation of the 'said' definition of Perimeter, and finally it was a one-sided talk where the teacher told learners the formula and procedure on how to calculate the Perimeter. Thus this was a non-interactive/authoritative communicative approach.

Teacher Nthabi continued her explanation on the use of the given formula and provided an example in which a student was invited to demonstrate the use of that formula. The teacher then invited the rest of the class to approve if the written answer was correct and finally summarised by alerting the learners to always start by writing the formula. Therefore, there were no pedagogical links made. The learners were only involved where they said "*yes teacher*" to approve Tsepo's answer as correct and only Tsepo was given the opportunity to work on the example silently without discussion or explanation, thus only the teacher was involved in the talk. The communication was therefore a non-interactive/authoritative communicative approach.

In the same sequence, the teacher went on to provide learners with a new formula for Area of a triangle and provided an example hence guiding them on how to identify the base and height of a triangle. The talk in this class therefore involved no pedagogical link-making. The learners were only involved when providing '*yes teacher*' response to the teacher's leading and confirmatory questions as she worked through the example and explaining the units of Area. The communication was therefore mostly one-sided hence indicated non-interactive/authoritative communicative approach.

Similarly, as the lesson went on, no pedagogical links were made by the teacher and the learners**.** Her talk was only aimed at guiding them in each group to perform correct arithmetic processes to arrive at the right answers. It was also focused on correctness of Tumo's answer that was displayed on the board. The talk was led by the teacher throughout, and learners only contributed by providing short answers in accordance with her leading and confirmatory questions. This therefore indicates that the talk featured an interactive/authoritative communicative approach.

In summary, in this episode only one pedagogical link was made (to support knowledge building: making links between modes of representation (that is, linking definition of Perimeter and algebraic representation) and the classroom talk involved five incidents of interactive/authoritative communicative approaches and one incident of interactive/dialogic communicative approach.

The concept of Area was treated as a unique entity for the type of shape in discussion. The emphasis was put more on the types of shapes for which the Area was to be calculated. This was done irrespective of the definition given and how each of the formulae for each shape's Area was derived or how those formulae relate or make connections between the types of shapes. From this point alone, it can be argued that the teaching was ritualised (concepts exist without Mathematical reasoning or origin, and there to be memorised as is).

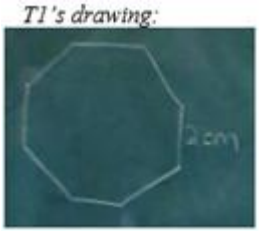
Viewed from the Commognitive perspective, in this episode, Nthabi's teaching could be argued to have been ritualised. The ritual nature of her teaching was observed in action sequences that involved: teacher providing the formulae for (the supposed to be) new concepts; providing the example in using such formula and leaving it written on the board for learners to refer to; inviting learner to present calculations on the board to show conformation to the given exemplified computational procedure; probing approval by the class to show uniformity in computational procedure and the correct answer. Though they were engaged in some answering of the teacher's questions, their responses did not show an attempt to provide reasoning as to why their answers were correct. Further, in most parts of this episode, the teacher involved colloquial discourses during explanations of how the formula works and while explaining and working on an example. This was intertwined with personalised and processual talk hence disobjectified discourses which further marked the teaching routines as rituals.

6.1.5 (Episode 5; Lesson 2) Drilling exercise on Perimeter and Area of n-sided polygon

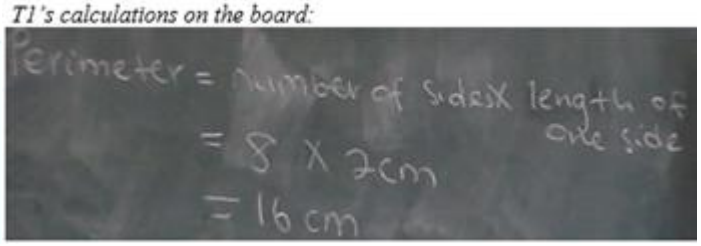
As a way of practically drilling learners and ensuring that they successfully calculated Perimeter and Area of n-sided polygons, Nthabi distributed some problem-set sheets among the learners. The questions in the problem-set demanded them to read the scenario, interpret it and answer questions related to Perimeter and Area of an irregular n-sided polygon. However, prior to the distribution of the problem-set and in order to prepare the learners for this particular tutorial session, Nthabi introduced and led learners (through an example) in calculating Perimeter of a regular polygon. On this discussion, she began by telling and showing (by writing on the board) learners that since all the sides of the polygon are equal, to get Perimeter, one has to multiply the number of sides by the length of one side.

105: T1: How many sides does this shape have?
106: Learners: Eight
107: T1: They are eight. If each side is 2cm how much is its Perimeter?
108: Leeto: Sixteen cm
109: T1: Sixteen? How did you find sixteen?
110: Leeto: I 'timesed' two times eight
111: T1: And we said that this equation works only if all sides are equal right?
112: Learners: Yes, teacher
113: T1: So we said how many number of sides do we have here? We have eight and one side; its length is?
114: Learners: 2cm.
115: T1: Is 2 cm, now we say eight times two is?
116: Learners: Sixteen.
117: T1: So, I was saying we should just remind ourselves about how to find the Perimeter of a shape.

T1's drawing:



T1's calculations on the board:



The teacher's review on the property of regular polygon and computational procedure for its Perimeter took partially an active instructional approach since the learners were reminded of these through a probe to which they responded correctly and easily since this was discussed in a prior lesson. However, this could have been a fully active instructional approach if the learners were given an activity or short problem to write and discuss on. This act occurred as the teacher's advance to rote use of the previously taught formula which did not show any attempt towards development of learners' deeper conceptual understanding. This therefore indicated the teacher's use of ritual routines which were further highlighted by her writing of the workings and formula on the board as she explained and probed learners. The

communication in this scene could be considered an interactive/dialogic communicative approach since both the teacher and the learners were talking and the learners' talk involved some explanation of their executed procedure in order to obtain their uttered final answer.

After providing a worked example on regular polygon, the discussion proceeded further to the Perimeter of an irregular polygon which brought back the add-all-sides computational procedure. Throughout the teacher's presentation, learners were led with leading and confirmatory questions in identifying the number of sides and their sizes for each of the polygons in the examples, and computation of their Perimeters (see extract below).

> **118: T1:** Now we are going to move on to another thing. Suppose you have... a bigger shape now, that we're supposed to find the length around it like. Let's do it together on the board to clarify it …the length of the upper side is? [*Pointing at a diagram on the board*]
> **119: Learners:** 12cm
> **120: T1:** What about this one? **[Learners:** 4cm] and this one is? **[Learners:** 3cm] what about this one? **[Learners:** 1.5cm] what about this one? **[Learners:** 3cm] And this one? **[Learners:** 4cm] And this one? **[Learners**: 6cm] what about this one? [**Learners:** 5cm] ... We said that when we are calculating the Perimeter of a shape we are adding all the sides, right?
> **121: Learners**: Yes, teacher
> **122: T1:** All the sides; that says we have how many sides? **[Learners:** One**,** two, three, four, five, six, seven, eight] so how much is the correct answer here? The Perimeter of this shape is?
> **123: Learner 17**: 33.5 centimetre.
> **124: T1:** They say it is 33.45? Is that so? You all got this?
> **125: Learners:** Yes, teacher
> **126: T1:** Do we have questions on that one? **[*Learners are silent*]**

The teacher partially used an active instructional approach during this introduction of the calculation of Perimeter of irregular polygon through a probe, while trying to help them identify all sides to be used and obtain the correct answer. This was also because the learners were involved in individual calculation process which led to their utterance of the correct answer during the teacher's questioning. These actions however followed a ritual routine sequence aimed at drilling learners on how the add-all-sides procedure works on different types of polygons, regular and irregular. The teacher-learner communication in this activity was interactive since learners were allowed to provide their answers to the teacher's questions. It was however not dialogic since there was no exchange of ideas but a rote response to the teacher's leading questions. Thus the interaction followed interactive/authoritative communicative approach.

Convinced that learners were able to find Perimeter of n-sided polygon (regular and irregular), Nthabi probed them about real-life application of the concept of Perimeter, to which they suggested a number of objects for which Perimeter could be calculated. In this exercise it could

be argued that the learners had some level of understanding of the concept of Perimeter as it applies to real objects.

> **127: T1:** Okay now I want us to think of the shapes that we want to find its Perimeter. Which shape can we workout its Perimeter? That of our classroom isn't it? The distance around this classroom isn't it? **[Learners**: Yes, teacher] what else? Yes!
> **128: Learner 18:** The Perimeter of the desk.
> **129: T1:** Of the desk, what else? Aha!
> **130: Learner 17:** The Perimeter of the land.
> **131: Learner 20:** The Perimeter of a dam.
> **132: T1:** Aha! What else?
> **133: Learner 19:** The Perimeter of the book.
> **134: T1:** Okay so now that we know what Perimeter is… we can find the Perimeter of every shape that we want. Is that clear? [**Learners in a chorus:** Yes, teacher.]

Since in this real-life examples making the learners were given a chance to provide their own examples one after the other, this could be regarded as an active instructional approach move by the teacher. She however provided the learners with the first real-life example with the aim to enable them to provide their own by aligning with her example. This therefore indicated the teacher's ritual routine aimed at directing learners into her way of doing things.

This idea of real-life examples showed that teacher Nthabi had a perception that learners could understand the concept of Perimeter better when they were given real-life examples. This therefore indicated her link-making to support knowledge building – making links between scientific explanations and real-world phenomena. This perspective was further affirmed by her response during the interview session. In responding to the question of helping struggling learners (while maintaining their autonomy and active participation) and that of the basic skills that learners need, Nthabi insisted that they need to be taught with examples from their real-life and they need to have the skill to relate classroom concepts with the real-life objects:

> *I think the first thing would be using examples that are… they are involved in real life situations. We do that often so that they realise that maths is not that complicated. It's something they deal with every day. Use examples that they are familiar with….*
> *I think they need to think critically…they need practical questions like the one on the tutorial whereby they see it. Suppose we make an example of trying to fit the tiles in their classroom and now we want to show them the sample of the first tile, its lengths or dimensions and then we ask them to find the total Area of the tile, to find the tiles that needed to fit that classroom. And yeah something practical, something that they see easily because learners at that age prefer seeing things than just hearing something whereby they need to imagine those.*

The teacher therefore concluded that since learners knew Perimeter they could be able to calculate it for any shape. In this discussion, the teacher did much of the talking through posing

questions and short explanations while the learners provided short responses accordingly. This therefore was an interactive/authoritative communicative approach since the learners were never given a chance to raise opinions or reasoning towards any explanations made.

For this part of episode 5, Nthabi's teaching involved some activities of active instructional approach which allowed learners to actively participate in their learning with less teacher assistance. These activities included: introducing a new shape with a learner probe on its properties; allowing learners to work on the example with the new shape to see if they could calculate correctly; and probing to seek learners' narration of their used procedure in obtaining the correct answer. Her attempt to actively engage the learners was further observed where she probed them to think and suggest any real-life objects for which they could calculate or measure Perimeter. However, the active nature of this part of the lesson was soon livened up by the teacher's direct instructional activity. She repeated the procedure that learners explained and provided the equation which works best for a regular polygon (multiplication of number of sides by side length), and worked on the example didactically to show the class how to obtain the correct answer. Though learners were probed through the computational process, it could be argued that they were denied the opportunity to come up with possible presentations of calculations other than addition.

In the beginning of this episode, the teacher introduced one more example to demonstrate to learners how they could use the 'taught' add-all-sides or multiply-by-number-of-sides procedures to calculate Perimeter of a regular 8-sided polygon. She therefore led learners through an arithmetic process to confirm their final answer, hence making no pedagogical links. However, after being convinced that the two procedures were memorised and learners could use them successfully, teacher Nthabi led them into connecting what they had been learning and practising on Perimeter to the real objects. This therefore indicated her leading learners to make pedagogical links between the concept of Perimeter, learned in the lesson, to real-life objects, thus their making links between scientific explanations and real-world phenomena.

The teacher-learner conversation which proceeded prior to the link-making exchange involved mostly the teacher's leading and confirmatory questions which demanded learners to provide short answers including recitation of their used procedure to get the answer they gave. Even the conversation in which learners were guided to making the link mentioned above involved the teacher posing a question for them to provide those real objects for which Perimeter could

be calculated or measured. This implies that the conversation involved interactive/authoritative communicative approach.

Nthabi's routine of telling and writing the example didactically, and leading learners through the computation process so that they produced answers in a chorus, proved to be rituals meant for learners' uniformity of procedures and answers. Though learners were given a chance to work on the example and narrate their computational procedure, before the teacher's presentation, that was purely narration of the procedure without her probe for their reasoning or substantiation on why the procedure works or why the answer was correct. This ritual nature of classroom routine was further displayed in the disobjectified (personal and processual) teacher-learner discourse during the probe for calculations towards the correct answer.

After distributing the problem-set sheets, Nthabi told the learners that the tutorial required them to calculate Perimeter and Area, and she repeatedly assured them that it was the same thing as that done in the examples she had provided. As the learners began working on the problem-set in groups, as instructed by the teacher, Nthabi randomly visited each group for marking and probing learners to interpret the questions and answer correctly. In one of her group-visits, she probed learners with questions which indicated that she needed them to think and try to make connections between the scenario and the concept of Perimeter learned during her presentation (that is, active scaffolding). However, after the learners' response (which indicated their failure to do such connection) she ended the discussion by telling them what the question needed them to do (that is, interpret it for them) (see the extract below).

> **135: T1 (to the group):** Around the shape. What about fence? Fence does not go around to that shape? Eh? We are still talking about length here; around that yard that Mr. Stue is keeping the animals. That says what are we calculating?
> **136: Member 1:** We are calculating Perimeter.
> **137: T1:** …Here we are calculating?
> **138: Members:** Perimeter.
> **139: T1:** Aha! Now how do we calculate Perimeter? *[Members are quiet]* Hm? How are we going to find it?
> **140: Member 2:** Teacher we calculate all the sides?
> **141: T1:** Mm, we are going to add all the sides. That is, you add the sides all of them to find that total length.

The teacher's posing of questions to learners as a way of providing active scaffolding showed her attempt to execute active instructional approach. She read the scenario and posed some leading questions as a way of channelling learners to the desired interpretation of the problem-scenario. This question-answer interaction indicated the teacher's use of ritual teaching routine

since learners were not probed to provide any reasoning to show understanding but only to remember and recite memorised definition of Perimeter. In his scaffolding probe and explanations, the teacher followed problem-scenario in making a connection between the real-life scenario and the definition of the concept of Perimeter. Thus she executed link-making to support knowledge building – making links between scientific explanations and real-world phenomena. The conversation between teacher and learners was interactive since they accordingly responded to her leading questions. It was however not dialogic since learners had to provide memorised taught name Perimeter and the procedure practised during the teacher's presentation, without own interpretive opinions, hence the teacher's use of interactive/authoritative communicative approach.

Teacher Nthabi's 'mixed-approach' *(active and direct instructional approaches)* teaching was observed in most of her conversations with her learners during her group-visits, as learners worked on the problem-set. As portrayed in the above conversation, the interactions mostly began with an active instructional approach in which the teacher posed questions which triggered learners' critical thinking and analysis of the given scenario and allowed them to figure out how to answer the subsequent questions. However, the probing usually ended with the teacher dictating and telling learners what they were supposed to do to find the answer (which was something they ought to have discovered by themselves as she probed with questions). A similar conversation was observed during the teacher's re-visit to group, in which the group had difficulty coming up with the narrative of what operation to perform to find the total length as demanded by the question (see the extract below).

142: T1 (to the group): How do we find the total length? Hm? Are we multiplying?
143: Member 1: We are going to add all the sides.
144: T1: We are going to add all the sides. How many sides do we have?
145: Member 2: We have 5.
146: T1: Five sides. Which is the first one? People, how many sides does this shape have?
147: Groupmates: Five sides.
148: T1: Five, okay which is the first one? [**Member 1**: One], the second? [**Member 1:** Two]. The third?
[**Member 1**: Three], the fourth? [**Member 1:** four], the fifth? [**Member 1:** Five]
149: T1: Now we're going to add all those sides isn't it? If this side is 13 meters, what about this one?
150: Member 2: Thirteen.
151: T1: It's also thirteen. If here it's five what about this one?
152: Member 2: It's also five.
153: T1: And this one?
154: Member 2: Five.
155: T1: That says we have thirteen, five, five, five, thirteen. You add them to find the total length, right?
156: Member 2: Yes, teacher.

The teacher-learner interaction here showed active instructional approach in the beginning and throughout the process of identifying the sides since learners were probed to provide answers which indicated their understanding or prior knowledge of properties of irregular polygons as taught. However, the learners were not given a chance to figure out the sides by themselves by interpreting the diagram hence their actions and the teacher's probe were rituals. The communication in this extract was interactive since the learners and the teacher were engaged in a question-answer interaction. However, learners were not given a chance to provide the explanations or raise some opinions with reasoning, hence the communication was teacher-authoritative, thus interactive/authoritative communicative approach.

Though in rare instances, Nthabi's probing in the group discussions did show indications of active instructional approach in which she asked non-directive questions and then left learners to decide on the next step to go about the calculations (see extract below).

> **157: T1 (to group)**: Gentlemen and the lady, how much did you get?
> **158: Member 1:** We got 18 meters.
> **159: T1:** 18? On the first one? How did you get it?
> **160: Member 1:** We add 13 meters and 5 meters.
> **161: T1:** Okay where does the Perimeter of this shape run? Can you show me with your pen? Where is the Perimeter of this shape? [*Member 1 traces the Perimeter by moving her pen along the sides*]. Does it end there? Remember, what is Perimeter? [*Member 2 traces the Perimeter by moving his pencil along the 5 sides of the shape*] Aha! Good. So what is the length there? What are the lengths that we are supposed to add there? What lengths are you supposed to add? [*Member 2 points at the 13m length then 5m length*] and? [*Member 2 points at the outer unlabelled longer side*] How much is that one?
> **162: Member 2**: 13 meters.
> **163: T1:** Aha, it's 13. Write it down maybe. On that picture write 13 so that you remember. Then what are these other lengths? What's the size of the other lengths?
> **164: Member 1**: 5 meters.
> **165: T1**:5 meters; so what are you supposed to add? To find the Perimeter what do you add? Find out.

In this extract, teacher Nthabi used active scaffolding to probe learners to remember and use the properties of regular and irregular polygons in order to identify the sides of the polygon which form its Perimeter. Though the teacher did not provide answers or explanations to show learners the sides of the polygon to use, this could not be seen as an exploration routine since the learners were not probed to provide reasons or substantive opinions to show understanding of the concept of Perimeter, hence a ritual was used. The communication between the teacher and the learners was interactive since they had to provide answers to the teacher's questions which led to their recognition of the appropriate sides to use. However, this communication was teacher-authoritative since her questioning was channelled to guiding learners into

identifying the appropriate sides. They were not allowed to provide new ideas or reason for their given responses. Thus the teacher used interactive/authoritative approach.

Generally, in this part of the episode, teacher Nthabi used mostly leading questions to try to direct learners to identify the number of sides of the given polygon and identify the size of each side including unlabelled sides. At some point, she used a repeat-and-expand method to try to approve learners' answers while telling them the procedure they had to use to find the Perimeter of the polygon. This indicated her use of direct instructional approach to channel learners towards the teacher's desired answer.

Teacher Nthabi was using some engaging-scaffolding in which she persistently asked learners some questions, related to the diagram and the question in hand, to guide them to identify all the appropriate sides to use for Perimeter of the shape. As opposed to direct instructional approach she used in other parts of the lesson, for this particular group Nthabi did not provide the explanation on which sides to use even though the addition operation was part of her questions. The type of questioning Nthabi used had some indication of her trying to use problem-solving strategy to allow learners to develop their conceptual understanding of Area and how it applies in real-life.

The scenario provided in the problem-set worksheet demanded learners to make a connection between the classroom-learned concept of Perimeter and the real-life concept of fence-around-the-yard. However, teacher Nthabi and her learners did not focus on this connection, instead they focused on the concept of Perimeter as practised previously in examples by trying to identify the number of sides and the size of each side of the diagram on the sheet. The class therefore failed to make any pedagogical links. Though learners were mostly involved in giving answers to the teacher's channelling questions, the conversation was mostly dominated by the teacher in trying to channel their answers towards her computational procedure of adding all sides. The conversation thus featured an interactive/authoritative communicative approach.

With reference to the latter three extracts, the Commognitive characteristics of Nthabi's teaching proved it to be ritualised. In all the three extracts, the teacher's questioning was focused on learners identifying the sides to use and how they chose to use them in computation of Perimeter or Area as demonstrated in previous examples. The concentration was not on learners' reasoning on why their ideas were correct. The teacher's interest was to see if the

learners could perform the computations as shown during the worked examples sessions. The ritual nature of her routines was further observed in her way of talk when attending learners in their groups. She talked of the computation of Perimeter and Area as processes and as resulting from the learners' actions, hence processual and personal – thus disobjectified discourses. The summarised analysis of teacher Nthabi's practices is presented in **Appendix K**.

6.2 Learner competences, classroom discourses and routines

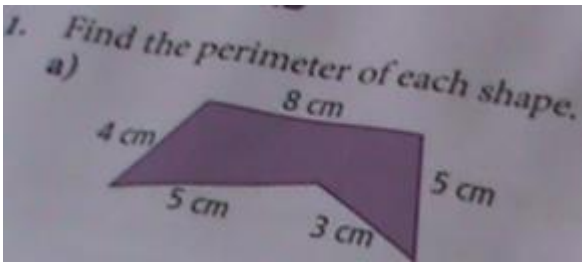
Nthabi's class teaching involved a learners' textbook exercise and problem-set activity besides the teacher's presentations, examples and mini-learner exercises. The textbook exercise and the problem-set activity were administered to the learners as a way of allowing them to put to practice the computational skills demonstrated to them and test their comprehension of the use of the taught procedures. The subsequent sections herein present the data and analysis of the learners' competences, discourses and routines as they worked on the exercise and the problem-set.

6.2.1 (Episode 6) Learners' competence and discourses while on Perimeter of n-sided polygon

Following a lesson sequence composed of explanations and worked examples, Nthabi eventually commanded her learners to work on the exercise provided in their textbook. In this exercise, learners were required to calculate the Perimeter of given polygons, regular and irregular. The purpose of the exercise was for the teacher to evaluate if the learners had grasped the computational procedure as presented in a series of examples just done. Though they were ordered to work in groups, for this part of the lesson, not much was discussed among the learners. They mostly worked silently and individually though they were seated in groups. To monitor their progress and accuracy in their calculations, Nthabi moved from group to group probing learners for what they had written. This act sparked some discussions between the teacher and the learners in each group.

Nthabi's duty was to proof-check if the learners had identified the correct sides of the shape to use and check the accuracy of their calculations. For this purpose, the teacher led the groupmates with leading questions to arrive at the final answer. Much of the learners' duty was to provide responses accordingly as they worked out each section of the computational process. The activity usually ended with the teacher marking with a tick on the group's exercise book (see the extract below).

01: Member1: madam, we are done with number 1.
02: Okay. How many sides do we have here? [*Seratsi counts the sides of shape (a) in the textbook*]
03: Seratsi: Five
04: T1: We have 5 sides. The first one is 8cm, 4cm, 5cm, 3cm, 5cm, and then 8 plus 4 is?
05: Seratsi: 12
06: T1: 12, plus 5?
07: Seratsi: 17
08: T1: Plus 3?
09: Seratsi: 20
10: T1: plus 5?
11: Seratsi: 25
12: T1: Then the answer is correct, do number (b). Number (b) [*T1 marks group's answer correct with a tick*]



In this teacher's marking duty, the act of posing questions was only intended to proof-check if the learners had identified and used all the sides of the polygon for Perimeter calculation and whether they have accurately executed the arithmetic process. This was without a probe for learners to reason for their answers as a way of checking their understanding of the concept of Perimeter. Therefore, the teacher and the learners used ritual routines aimed at practising and perfecting the learners' use of the taught procedures and arithmetic process. The communication in this process was interactive since the learners were responding to the teacher's leading questions. It was however authoritative since the learners were not probed to provide opinions or reasoning towards their answers. Thus the teacher used interactive/authoritative approach.

This kind of discussions however were observed only in some instances, while in others the teacher probed by posing rhetorical questions to which she immediately provided answers by herself as a way of showing the learners where they were incorrect and hence providing them with the correct information. Further, Nthabi inspected the learners' work and marked with a tick if incorrect. For instance:

> **13: T1 (*to group*)**: Yes? Number 1 is correct. Let's see; how many sides do we have? [*Mollo counts the sides of a shape in the textbook*] How many are they? Five! Then we have 1, 2, 3, 4, 5 [*T1 says pointing at the dimensions of the shape, that the group has written in their exercise book*] the answer is 25cm, okay. [*T1 marks the group's answer correct with a tick*]

The communicative interaction between the teacher and the learners in this episode was mostly about her inspection of their group work to check if they were correct. Therefore, the questions she posed demanded learners to provide answers to the arithmetic process and briefly narrate the procedures they had used to get their answers. The learners were given a chance to talk but

only for providing answers to numbers added by the teacher as she went through their work, thus their communication was interactive yet authoritative by the teacher.

In this part of the lesson, learners were given a chance to talk into their workings to show if they had accurately performed the exercise. However, the processual nature of their talk with the teacher indicated that this routine was a ritual with their answers lacking reasoning/substantiation of why the calculations were correct that way. Learners showed no intention of elaborating on the workings they provided, probably because the teacher's questions did not demand them to. For instance, while still seated in their groups, one of the learners, '*Seratsi silently continues writing calculations for question (b), while there is no observed input from groupmates*' (Direct copy from field notes).

6.2.2 (Episode 7) Learners' Competence, Discourses, Routines and interactions on Perimeter of Triangle (Language fluency indicates learners' conceptual understanding)

Besides the exercise from the learners' textbook, Nthabi provided them (in their groups) with a problem-set sheet. The problem-set consisted of a scenario, related to real-life objects and people, and subsequent questions demanding learners to calculate Perimeter and Area of different parts of the given polygon. Different groups tried to read and interpret the scenario and the questions. However, most groups had brief discussions which indicated their difficulty to interpret the questions (relate the real-life scenario, the classroom-taught concept of Perimeter, and the given diagram). While taking rounds from group to group, teacher Nthabi had to guide the learners into interpreting the questions and ended up eventually telling them what the question needed them to calculate (thus interpreting the problem for them). The following extract exemplify learners' discussions and interaction with the teacher during her group visits.

> [*The group A members are sitting silently, with a worksheet in front of them. After a short while, one of them hesitantly reads out the question quietly*.]
>
> **14: Tim (*Reading softly*):** "Mr. Stue has a yard in his farm where he keeps his animals. The yard is a 12-sided regular polygon. The diagram shows part of the yard in which Mr. Stue keeps his sheep" … "…total length of fence required to enclose the part in which Mr. Stue keeps his sheep".
> **15: Mollo:** This one is equal to this one. [*Pointing at the two outermost sides*] This one will be… [*Points at a side labelled 5cm and another short one next to it*]
> **16: Tim:** This 5 meters is in this three parts [*pointing at the three shorter sides. He labels the other two short sides "5m" with a pencil*]
> **17: T1 (*to the group*):** Around the shape. What about fence? Isn't fence around that shape?
> **18: Member:** It's around the shape.
> **19: T1:** We are still talking about length here.
> **20: Mollo:** Yes, teacher

21: T1: Around that yard that Mr. Stue is keeping the animals.
22: Mollo: Yes, teacher.
23: T1: That says what are we calculating?
24: Mollo: We are calculating Perimeter.
25: T1: Aha! Now how do we calculate Perimeter? How are we going to find it?
26: Mollo: Teacher we calculate all the sides.
27: T1: Mm, we are going to add all the sides; that is, you add all of them to find that total length…do that then.

In this problem-solving session (shown in the above extract), the learners in the group showed some level of competence and understanding of properties of regular and irregular polygons since they were able to read and interpret the problem-scenario and identify all the sides of the polygon on the diagram. However, their discussion did not involve the idea of fence around the yard which was part of the problem-scenario. This therefore indicated their lack of problem-solving skills. This was also recognised by the teacher hence she probed the group to consider the idea of fence and relate it to the definition of the concept of Perimeter. The learners' discussion prior to the teacher's visit was focused on their process of identifying the measurements for all the sides of the polygon to be used for calculation of its Perimeter. Their talk therefore did not involve any argumentative reasoning, hence an indication of their use of ritual routines. While discussing on their own, the learners' discourse was mostly about the mathematical objects existing the polygon understudy and it was objectified (structured and impersonalised).

Upon the teacher's arrival at the group, the communication focused on the idea of fence as representation of the concept of Perimeter, thus the teacher posed a series of leading questions to help learners utter the process for calculation of Perimeter. This therefore indicated the teacher's use of ritual routines since learners were not probed to produce some argumentative reasoning or provide the final narratives around the problem at hand. The teacher mostly used personalised and processual discourse (hence disobjectified) where the teacher and learners discussed Perimeter as the process of adding the sides of polygon which learners perform to obtain a certain value. As the teacher probed to direct them to identify the concept to be calculated, she used leading questions to which the learners accordingly provided short answers without raising own opinions or providing some argumentative reasoning. Thus the teacher used interactive/authoritative communicative approach.

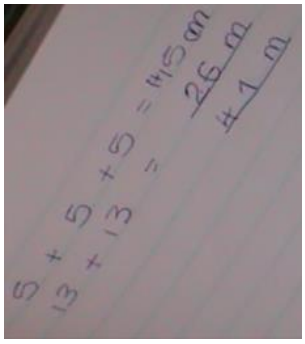
In the instances presented in the latter three extracts and preceding conversations, the learners were reading and trying to discuss in English until the teacher had to come to their rescue as they showed difficulty of interpreting the scenario and questions. Though language is not part

of the analysis in this study, it seems most of the learners were having a problem reading or interpreting the questions when they communicated in English. On the other hand, some instances showed that they were able to express their understanding and interpretation when they discussed in their home language (Sesotho). This can be substantiated by citing the instance involving the selected group who were able to interpret the questions and express their understanding of it when they were using their home language, Sesotho, during their discussion. Their conversation is shown in the extract below.

Learners' Sesotho conversation	**English translation**
[*group members are silently starring at their worksheet, meanwhile Seratsi points at the sides of the diagram with a pencil as she tries to explain to groupmates]* **28: Seratsi**: Mona e ntsele 5, mona ke 5, le mona e ntsele 5 [*she points at the three shorter sides*] Mona ke 13 mona ke 12 …Hothoe total length of fence required to enclose this part [*she stops reading*] … Hothoe total fence required moo? Ho thoe he has a farm e 12-sided. Mona ke li side tse kae? Tse five [*she says as she points at the diagram*] Nthoena ke fence, mona ba bua ka yard hore na e kae. Elore re tlametse ho tlo batla fence… ho tlo hlokahala e kae ho koala karolo enanang e … **29: Tuki:** Ee naa rea e sebelisa? [*he asks Seratsi pointing at the side labelled "12m"*] **30: Seratsi:** A.e, mona ke height mona **31: Tuki:** Ee naa re tlo e sebelisa? [*He asks pointing at the "12m" side*] Kapo re sebelisa 1, 2, 3, 4? [*He points at the four longer slanting sides*] **32: Seratsi:** Ena re tla e sebelisa ha re tla mona re batla Area ... mona re tlo batla Perimeter ea ho potapota mona *[moving her pen along the edges of the shape*]	**28: Seratsi**: It's still 5 here, here it is 5, even here it is also 5 [*she points at the three shorter sides*] here it is 13 here it is 12 …they say the total length of fence required to enclose this part… [*She stops reading*] … they say total fence required here? They say he has a farm that is 12-sided. How many sides are here? They are five [*she says as she points at the diagram*] this is a fence, here they are talking about the yard, we need to find the fence, how long is it, how long is needed to cover this side…. **29: Tuki:** So…do we use this one? [*he asks Seratsi pointing at the side labelled "12m"*] **30: Seratsi:** No, this is height. **31: Tuki:** Are we going to use this one? [*He asks pointing at the "12m" side*] Or should we use 1, 2, 3, 4? [*He points at the four longer slanting sides*] **32: Seratsi:** This one we will use to find Area when we come here… here we want to find Perimeter around this shape here *[moving her pen along the edges of the shape*]

In this extract, one learner, Seratsi, showed understanding of the problem-scenario and was able to make connections to the given diagram, and the concept of Perimeter just learned during teacher's presentation. Her ability to elaborate the information to the group using the home language (*Sesotho*) indicated her use of explorative routine (graced by elaborations and deeper thinking) in making connections between real-life situations and the classroom-learned concept of Perimeter. Though the discussion seemed single-sided (since Seratsi had been doing all the decoding and elaboration), the groupmates showed responsible and collaborative agency in reading and interpreting the scenario. Tuki's question about the use of '*12 m'* as part of calculation of the '*total length of the fence'* indicated his lack of understanding of the concept of Perimeter. However, the interaction between the groupmates indicated their effort and

persistence to interpret and understand the scenario with the aim to correctly attempt the questions. Therefore, after a long interactive/dialogic discussion, they came up with the correct calculations of the required Perimeter (see the snapshot).



Though the group's discussion was in their home language, their discourse was more formal (consisting of mostly mathematical jargon in the problem-scenario and question) and to some extent objectified (most of the group's talk, especially Seratsi, about mathematics terms as independent of them as humans) hence their routines could be considered as explorations.

Overall, in this episode learners were given a problem-set to work on as a way to challenge their knowledge acquisition on the concept of Perimeter. When the learners showed difficulty interpreting and connecting the given scenario to the concept of Perimeter taught through example demonstrations, the teacher intervened and started guiding them with a series of leading questions in order to help them identify which concept they had to calculate. In their conversation with her, the learners had a chance to respond by showing parts of the scenario they understood and identified sizes of the sides as pointed and directed by the teacher. The learners however, were just following the teacher's guide to arrive at her most desired response in answering the given question under the problem. The conversations therefore followed an interactive/authoritative communicative approach.

It could further be argued that learners were able to express their understanding and interpretation, of the given scenario and subsequent questions, when they discussed in their home language. In the three extracts, the somewhat hesitant talk among the learners indicated (to their teacher) their difficulty to interpret the questions, hence the teacher intervened in order to keep them actively participating. This observation resonates with Nthabi's interview responses on her understanding of learner-autonomy in a mathematics classroom. She insisted that in order to be considered autonomous, able to develop conceptual understanding, and

maximise their creativity and participation, learners should be allowed to communicate in their home language since it allows them to express themselves:

> *…the first one would be the language because in most cases it becomes the barrier, so it happens that even when they have great ideas, they can't say them because they cannot say it in English. So letting learners to speak in their own language makes it easier for them to bring everything that they think of so that with guidance of the teacher we translate that to English. Unlike when you are teaching Maths, they understand the concept, but presentation of the answer is the problem because of the language. So encouraging their language in class would be one of the things that I would allow so that they feel to communicate and talk.*

In terms of the Commognitive properties of their conversation and actions, the discussions in the three preceding extracts could be perceived mostly as rituals perpetuated by the teacher to guide and ensure learners' memorisation and retrieval of the concept of Perimeter as it applies to real-life situations as narrated in the scenario. This was further attested by the learners' failure to read and interpret the scenario and their dependence on the teacher's explanation and probing to come up with the required responses. Furthermore, the disobjectified nature of the teacher's probe and explanations led to learners disobjectified discourses as they responded to her questions or conformed to her confirmatory questions, hence their learning routines became rituals.

6.2.3 (Episode 8) Learners' Competence, Discourse, Routines and interactions on Area of Regular Polygon

Following their discussion, on part of the problem-set about calculation of Perimeter, Nthabi's learners were given a command to proceed to a question about calculation of Area. The question demanded learners to interpret the scenario, calculate the Area of one triangle and use knowledge of properties of a regular 12-sided polygon to find its total Area. For this task, the learners were ordered to work in groups and discuss their plan of operation. Like the rest of the class, a group of three learners, Tuki, Pali and Seratsi, attempted the question in trying to come up with the correct answer. The group began by reading and trying to interpret the given scenario and connect it to the question at hand. They then brainstormed the procedure they had to take. In their uncertainty, they decided to calculate the Area of a single triangle on the given diagram and multiply by three for three equal triangles on the diagram, or perform addition operation three times. However, most of their discussion was on identifying the lines in the triangle which represented the height and the base of that triangle.

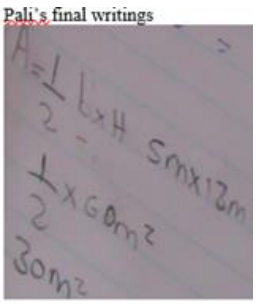
33: Seratsi (*to groupmates*): Here is the base, It's 5 [*she points at one of the "5m" sides*] Height is this one [*she points at the side labelled "12m"*] isn't it that, we are going to multiply this one, this one, and this one?
then add them?
34: Pali (*to groupmates*): Soo… what is this side? [*She points at one of the "5m" sides*] is this one a height? [*She points at the side labelled "12m"*]
35: Seratsi (*answering Pali*): Height is this one [*she points at the "12m" side*]
36: Pali: And this one a base? [*She points at one "5m" side*] So this shape is equals to this one? [*She points at two of the triangles in the diagram*] [*Seratsi circles "12-sided regular polygon as she explains to Tuki*]
37: Tuki (*to groupmates*): This is base, isn't? [*He points at the shortest side of the middle triangle*]
38: Seratsi: Mm… here it is, already written [*she points at the side originally labelled "5m"*] then we say…
39: Tuki: Here is the base [*He points at the side originally labelled "5m"*]

In this part of the learners' problem-solving session, the group focused on the process of identifying the sides of a single triangle which could be used as the height and base of such triangle. Their struggle to agree on the sides indicated their lack of understanding of the properties of regular polygons and an isosceles triangle. Their discussion did not include the idea of fence around the yard as dictated by the problem-scenario hence they could be said to lack problem-solving skills. However, their discussion seemed explorative since they were not relying on any pre-discussed ideas but a pure study of the polygon in the question and its visible properties. They were also involved in a mathematical discourse since their discussion involved only the properties of the polygon including the triangles in it. Since there was a fair exchange of ideas between the learners as they executed their discussion, the group interacted through an interactive/dialogic communicative approach.

It would seem the group had successfully memorised the formula for calculation of Area of a triangle since the major struggle they had was to identify the correct lines on the diagram to substitute for height and base of the triangle in the formula. In their discussion, one of the groupmates, Seratsi, seemed to have correctly identified the height and the base of the triangle and had a suggestion to use addition (of Areas for the three triangles in the diagram) to find the total Area required. Each of the groupmates made their suggestions and posed questions to mates about the sides which could be the height and the base of the triangle. Even so, Seratsi insisted on her original suggestions, hence the group had to use her suggested measures and used them to calculate, correctly, the Area of the triangle. However, Pali had already written her calculations using 13 (instead of 12) as the height of the triangle which gave her 65 (instead of 60). Before Seratsi could convince the groupmates on her suggestions, the teacher approached the group and showed them the correct measures to be the base and the height,

hence led them (by leading questions) through the computational procedure to find the correct answer (see the extract below).

> **40: Seratsi (*to groupmates*):** It's base times height? We are supposed to find the Area of this triangle, for this part and this part. [*Seratsi points at the 3 triangles in the diagram*]
> **41: Tuki:** We are going to say 13 times base for this part.
> **42: Seratsi:** Not 13. Height is 12, it is here, it is already given, here it is, do you see? [*She points at the side labelled "12m"*]
> **43: T1 (*to group*):** How is it going? [*Pali shows T1 their calculations in the exercise book]* And now you're saying, okay this is 13? Is the height really13, people? [*Members are silent*] But it's given, it's 12 [*Pali erases 13 and replaces it with 12*] So now how much is 12 times 5? [*Members are silent for a while*]
> **44: Members:** 60.
> **45: T1:** 60. Therefore this time we have 60 here. [*Pali erases "65" and writes "60" instead*] half of 60?
> **46: Members:** 30.
> **47: T1:** Are these units correct for the Area? [*T1 points at the "60m" written by Pali]*
> **48: Seratsi:** Meter Squared.
> **49: T1:** [*Pali writes "m^2"*] (yes)



As presented in this extract, though learners were able to remember and write down the formula (for calculation of Area of triangle), they showed lack of understanding of the concept of Area of triangle and properties of triangles since they were not able to use the appropriate lengths/sides of the triangle to substitute into the formula, hence an indication of their incompetence in terms of properties of an isosceles triangle and the concept of Area. Since there was an exchange of words between the learners as they tried to interpret the scenario and identify dimensions of triangle to substitute in the formula, their interaction was interactive/dialogic.

When realising the learners' difficulty, the teacher guided them to identify the sides of triangle which represent its height and base by posing an explorative question. However, the question became rhetorical since the learners did not answer, hence the teacher told and showed them the sides for height and base, then guided them through the computational process by questions (in an authoritative manner) to calculate accurately. This was therefore a further indication of teacher Nthabi's interactive/authoritative communicative approach.

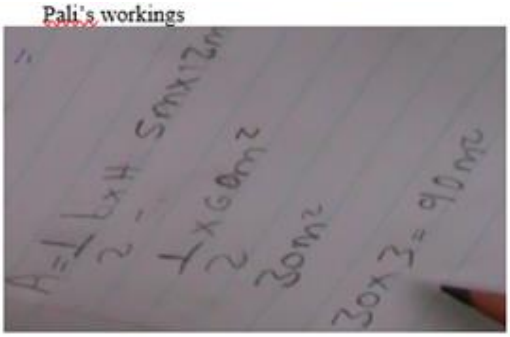
In terms of Commognitive properties of the learners' discourse, they tried to be more explorative in their routines, especially Seratsi. This is due to the fact that they tried to elaborate and reason on their computational choice of finding the Area of a single triangle first, then

followed by multiplication by number of triangles or adding them. However, the group's routines could not be considered fully explorative since they talked of the concept of Area as a process of multiplying or adding (processual discourse) and as an entity that exists when they perform such operations (personalised discourse), hence their discourse was disobjectified making their routines to be partly ritualised.

After the teacher had directed them into getting the answer for a single triangle, the group decided to multiply the answer by three, based on the three congruent triangles they saw on the diagram. However, this latter operation was incorrect since the question demanded them to calculate Area for the whole 12-sided polygon (for which the 3-triangle diagram would only be a part) (see extract below).

[*Group members continue to discuss after T1 has addressed their mistakes*]
50: Tuki (*to groupmates*): Which question are we doing?
51: Seratsi: We are doing this one.
52: Pali: 30, how many 30s are we doing now?
53: Seratsi: 30 times 3.
54: Pali: Oho [*Pali writes: 30 x 3*] equals…
55: Seratsi: Ninety [*Pali finally writes: A = 90m²*]

Pali's workings



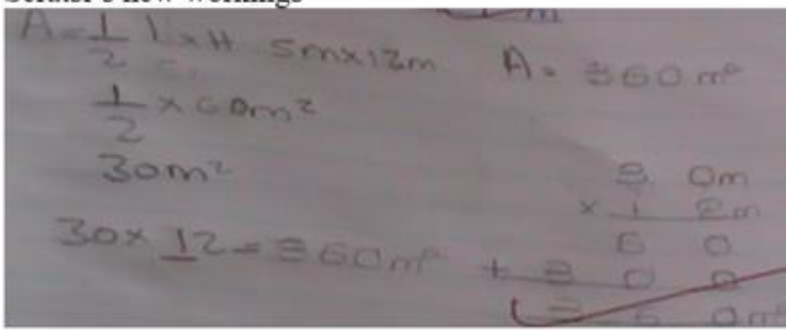
The learners' idea of multiplying the Area of one triangle by 3 indicated their further understanding of the properties of regular polygons. However, this also implied that they had not understood the demands of the problem, which indicated their lack of problem-solving skills.

In her monitoring duty, Nthabi arrived at Group A once again and realised that their multiplication by three was an incorrect choice. She then tried to probe the group so that they could reason for their choice of multiplication by three, the question which, however became rhetorical since the teacher immediately went on to remind the learners that the question was about 12-sided regular polygon hence led them to multiplying by twelve instead. As a result, the group had to rewrite their calculations, but this time multiplying the Area of one triangle,

30, by twelve, getting a 360 which the teacher eventually marked correct with a tick (see extract below).

56: T1 (*to group*): Okay where is this coming from? This 3? ...we multiplied by 3 because?
57: Pali: The shape has…3…
58: T1: We have 3 sides? Remember the question said we have how many sides? [*She underlines "12-sided" in the problem-scenario on the sheet*]
59: Seratsi (*hesitantly*): Twelve
60: T1: This means that here only 3 sides are shown but the shape has 12 sides, right? That says we're going to multiply by 12 not 3, right?
61: Tuki: Yes madam
62: T1: Mm, let's correct it then. [*Pali erases the "3"and replaces it with 12, teacher finally marks with a tick*].

Seratsi's new workings



The learners' conversation showed their exchange of ideas to identify the correct dimensions to use and the arithmetic processes to follow. This therefore indicated their use of interactive/dialogic communicative approach. However, this approach was spoiled by their teacher who intervened with the purpose of providing scaffolding which seemed to be too elevated since she authoritatively provided the explanation and direction of what to do. Therefore, the conversation in the presence of the teacher became a bit interactive yet authoritative. Her scaffolding was driven by explanations and directive leading questions which showed learners what to change in their workings. This therefore formed part of the ritual perpetuated by the teacher to correct the learners' work which did not guarantee whether the learners' change of workings indicated their understanding of the concept of Area or properties of a regular polygon or the problem itself.

In this episode generally, the learners in Group A showed their good memory of the formula for the Area of a triangle and they were somehow able to interpret the question, hence their decision to calculate the Area of one triangle to be followed by multiplication by number of congruent triangles. However, since they were much absorbed by their discussion, they probably forgot to re-read the scenario to realise that it directed them into calculation of the Area of a 12-sided regular polygon for which the diagram was part. With the exception of one

groupmate, Seratsi, the group showed that even though they had the formula in their memories, they had not understood how it came to be and why it was applicable for Area of a triangle. This was observed in their difficulty to identify the sides of triangle to substitute as the base and height of the triangle. Though they finally agreed on the correct multiplication process of 2-digit numbers, and they arrived at a correct answer, Group A members had a difficulty with this operation hence they committed a few computational errors before they could arrive at the correct answer.

The learners in this group showed a rather weak level of problem-solving skill. Their discussion, specifically on the Area concept, was purely on the use of the formula (substitution of the height and base) and the arithmetic processes (multiplication and addition). There was no reference to the problem or its solution (*Area of the yard occupied by all animals*), which would have been the reason for performing the calculations. Further, their discussion and computations had little (to none) indication of any manipulative skills and critical thinking (dependence on memory of formula and multiplication process).

The learners' difficulty in identifying (and reaching agreement on) which sides (13m, 12m or 5m) were to be used as the base and height of the triangle indicated their reliance on ritual routines, in which case they only memorised the formula and the computational procedure after substituting the measures. The discussion was, to some extent, single-sided since the two groupmates, Tuki and Pali, were mostly passively listening to Seratsi and most of the time Seratsi had to make arguments and final decisions on what measures to use and what (and how) operation to perform.

In terms of the Commognitive properties of their discourse, Group A's activities were observed to be mostly rituals and involving colloquial discourses. During their discussion on the choice of dimensions to substitute into the formula, each of the discussants made their suggestions by trial and error without actually giving reasoning (from known properties of the polygon or any information from the problem scenario) as the basis for their choice. On the same issue, though Seratsi showed some expertise in the choice of the correct dimensions and sequence of operations (which operation follows after which), she did not provide the group with any substantiation for her choices. Throughout their discussion, Seratsi seemed to possess all the powers of the group while the other groupmates had to just operate as she did and suggested, to be considered correct. This ritual nature of their routines was further affirmed by the

disobjectified nature of their discourses. They talked of the Area to be obtained as a process of multiplying base by height by half and adding the Areas to obtain the total Area, hence the discourse was processual. They also mostly talked of their activities as the entity of their doing (use of: *we, I, re…*) hence personalised discourse. The summarised analysis of learners' practices in Nthabi's class is presented in **Appendix L** and **Appendix M,** as an example of how all the data analysis chapters were analysed.

6.3. Nthabi's responses to the Interview Questions - Teacher's understanding of her role

This section presents Nthabi's responses to the interview questions. The presentation includes the analysis on how these responses convey her understanding of the expectations of the curriculum and her role as a teacher in a learner-autonomous and active-learner-based mathematics classroom. In the extracts presented, Nthabi responded to seven main questions accompanied by some follow-up questions intended to seek further clarifications and information. Each extract presents mainly the teacher's response to the posed question and at some instances responses to follow-up questions.

6.3.1. Question 1: How do you feel about the new integrated curriculum, and what are its main expectations, especially on the teaching strategies and learners' classroom behaviour and how do those compare with the old curricula expectations?

> **Nthabi:** *… I think this curriculum is too much for Grade 8 students, especially after everything they have been through… I think it's too much for them to understand it, it's challenging and it needs a lot of time. Yes.*
> *… I think what is expected is that learners are the ones to do the work, with guidance of the teacher here and there. They are supposed to come with ideas on how they want to learn so that they learn at their best… level, unlike in the older times whereby the teacher used to do everything this time the learners are the ones to do the job for themselves.*

In response to her perception and understanding of the expectations of the new curriculum, Nthabi commented that the curricula content is of a higher level for Grade 8 learners. She added that its expectations include allowing learners to contribute more than the teacher in their learning process with limited assistance from the teacher, and learners are expected to make decisions on what to learn so that they learn at their comfort levels. This indicated her perception of this curriculum as misplaced at Grade 8, and understands it to be demanding self-driven active learning and learner-autonomy.

6.3.2. Question 2: What do you understand by active learning and teaching, and learner-autonomy in a mathematics classroom, and what role do you play in order to facilitate active learning in your mathematics classroom?

> **Nthabi:** *Active approach? Um… I think it's whereby learners have to participate and be the ones active throughout the lesson. The teacher yes, may teach, but with guidance of course but learners are the ones to participate more.*
> *Eh… my role would be going through their work checking if they are on the right track because where learners are only by themselves, they easily make mistakes and enjoy playing instead of learning so, I would be guiding them to see if they are doing the correct work.*
> *Learner-Autonomy… I think learners are supposed to be using the language that answers what they are familiar with, them using their mother tongue instead of letting language to be the barrier of their learning.*

Nthabi described active instructional approach as a learning situation where learners actively participate during the lesson, while the teacher's role is to provide limited guide, and monitoring learners to check if they are doing the work correctly. She described learner-autonomy as a situation where learners should use their home language in learning to avoid language-as-a-barrier. This indicated her understanding of learner-autonomy as freedom to use home language as a medium of discussions and instruction.

6.3.3. Question 3: With your definition of learner-autonomy and active instructional approach to teaching and learning, how do you teach Mensuration to help your students comprehend the topic thoroughly?

> **Nthabi:** *…In grade 8, I prefer to use demonstration and discussion so that learners communicate. Otherwise brainstorming for introducing lessons that they are familiar with.*

For teaching the concepts of Mensuration, Nthabi claimed that she preferred demonstration and discussion to allow learners' communication. She further pointed out that she uses brainstorming sessions to establish learners' prior knowledge. This indicated her preference for direct instructional approach coupled with communicative approach and inquiry-based teaching.

6.3.4. Question 4 (a): In a learner-autonomous mathematics classroom, how do you approach different learning styles?

> **Nthabi:** *Ok.… I think by letting learners work in groups so that they share ideas and as the teacher I go around groups to see if they are doing the work properly, letting discussions take place. Where demonstration is needed in a certain group I do that for them so that by the time I leave that group, I know they are doing the right thing. And then, walking around explaining here and there so that learning takes place in the class.*

To cater for different learning styles, teacher Nthabi suggested allowing learners to work in groups to share ideas, and the teacher's role being to move around among the groups to monitor the quality of work learners are doing. She describes the purpose of group visits as demonstrating for groups to ensure that each is doing the right thing, and to explain some things to make sure learning takes place. This response indicated that though she believed in communicative approach through discussion, Nthabi still considered her role as authoritative and providing elevated scaffolding through direct instructional approach.

6.3.5. Question 4 (b): In a learner-autonomous mathematics classroom, how would/do you encourage your students to express their creativity, and maximise participation?

> **Nthabi:** *I think the first one would be the language because in most cases it becomes the barrier, so it happens that even when they have great ideas, they can't say them because they cannot say it in English. So letting learners to speak in their own language makes it easier for them to bring everything that they think of so that with guidance of the teacher we translate that to English. It becomes more fun when they understand what they are doing. Unlike when you are teaching Maths, they understand the concept, but presentation of the answer is the problem because of the language. So allowing use of their language in class would be one of the things that I would encourage so that they feel free to communicate… yes in their own mother tongue…their language.*

For facilitation of learners' maximum participation and encouragement for creativity, Nthabi suggested allowing the use of learners' preferred language (mostly the home language) to enable them to easily and successfully express themselves freely, hence creating opportunity for their autonomy and active engagement.

6.3.6. Question 5: What classroom practices do you think mathematics teachers should master in order to promote learner-autonomy and facilitate active learning to maximise learner conceptual understanding?

> **Nthabi:** *I think the first thing would be using examples they are involved in real life situations; use examples that they are familiar with; including games through learning to make them to enjoy, we also give them that feel of playing while learning is taking place; allowing learners to work in groups. Sometimes it happens that learners are free to talk to other learners instead*

of the teacher. Like if there is a misconception, it may help that they talk to one another so that they help each other. But that still needs the guidance of the teacher so the teacher should allow groups working, and also try to divide the attention to everyone because once they feel neglected, they start getting bored and not interested in learning. Attend those that do not even understand what you want them do, explain to them and see that they do the first step with your help.

For the promotion and facilitation of learner-autonomy and active engagement, Nthabi suggested that mathematics teachers must cite examples using concrete objects available in learners' real-life situations to allow all learners to understand without difficulty. She further suggested the use of games to increase fun while learning occurs concurrently, and allowing group work so that learners are free to discuss and share ideas. This indicated her considered real-life examples, games, and discussions as elements of LA and active engagement.

6.3.7. Question 6: How do you feel about the way you conducted the lessons, and to what extent do you think the learners were autonomous and actively involved in the learning processes?

> **Nthabi:** *I don't know but what I can say is that… here the class that we have, these learners are not really prepared for the content that is bigger like that one… because they have been through a lot… teacher's strike, covid and everything staying at home…We are trying to go step by step starting with easier things, but now with that content, they were a bit shy to see other people inside the class. Visitors, so most of them didn't participate more which is something they don't do usually, but I would say overall the class went well because there was participation though it was not fully.*
> *I wouldn't say that they were free, they were quite shy, not talking even in groups. I realised that some people were not participating. Only one person was the one writing and doing all the work so I wouldn't say they were free. So rating them ah……on the scale of 10 I would say probably 5 or 6… they still demanded a lot from the teacher, they couldn't do things on their own that much.*

In reflecting on the observed lessons, Nthabi admitted that her class was not very active and learners were not competent to her satisfaction and were not operating independently. She however stated that in most groups, only certain individuals were actively engaged yet all the learners still needed her elevated scaffolding and guidance. The learners' incompetence, lack of active engagement and dependence on the teacher's authoritative guidance, were all blamed on the high level of content for Grade 8, time lost due to COVID-19 disruptions, and the presence of visitors (observers). This response indicated that Nthabi believed her learners were not competent enough to understand the content taught to them hence she had to always provide authoritative scaffolding and explanations to make things simpler for them.

6.3.8. Question 7: What do you think was your role in this classroom during this lesson, and what was the role of the learners and what improvements would you make in your teaching approach to maximise active learning, promote learner-autonomy and conceptual understanding?

> **Nthabi:** *…my role was to explain what we are doing today and…see that they understand how we calculate the Area of those shapes…the topics are advanced so I had to read and explain for them to answer…*
> *Ah I think I should include the examples that they are familiar with by grad tutorial or the worksheet that they have which was talking about the yard and everything. Because the content is new so they need to know that it's something that they are familiar with. The other thing would be working on addition of numbers because somewhat they got wrong was addition yet the concept wasn't about adding numbers, instead it was calculating Perimeter. So I think before going to that topic, we should have done a lot, not just go to it directly.*

Nthabi further revealed that her major role throughout was providing the necessary explanations of concepts and computational procedures and assist learners to understand by reading the questions and guiding them how to calculate. She further insisted that to improve the learners' competence, and promote autonomy, teachers should provide examples which involve things that learners are familiar with, including real-life objects, and the teaching should concentrate more on basic concepts such as arithmetic of basic operations. This indicated that she preferred direct instructional approach and considered learners as less capable. It also indicated that she considered learner-autonomy as a teaching-learning situation that relates closely to the use of real-life examples.

6.4. Summary of Nthabi's instructional approaches and data consolidation (interview responses vs observed actions)

The discussion in Nthabi's data presentation shows that her teaching consisted of both direct and active instructional approaches. In each episode, learners were exposed to some activities which promote their active learning. Though these activities were rarely visible, they contribute to the diversity of teaching approaches which Nthabi considered suitable for teaching Mensuration concepts.

Nthabi's actions of active instructional approach included: giving learners an assignment on the concepts prior to the lesson; probing learners to define the new concepts, as part of the lesson introduction; probing learners to comment on the accuracy of each other's solutions for

correction or approval; interactively probing learners to seek their thinking/suggestions on computational procedure; inviting learners to demonstrate calculations on the classroom board; and using engaging-scaffolding to help learners make connections between real-life scenarios and concepts learned in class. However, in most of these probing sessions, the teacher ended the discussion by telling learners what they were expected to do/find. This therefore showed heavier leaning towards direct instructional approach. It was in very rare instances where the probing session would remain open for learners to make final decisions on what to do.

Furthermore, Nthabi grouped learners to work on a problem-set, which generated some discussions among groupmates. This observed practice concurs with Nthabi's claims in response to an interview question. In her response on the question on teaching methods usually used, Nthabi insisted on discussion as the most appropriate since it allows learners' to share their ideas.

Contrary to the above discussed approach, in both lessons where Nthabi was teaching Perimeter and Area, her most dominant instructional approach was direct instructional approach. Nthabi was observed introducing each concept, mostly by giving learners a definition, followed by probing for the computational procedure which however, became rhetorical in that whether learners answered correctly or incorrectly, the teacher provided the formula and worked-example. In each example, she would work through it step-by-step while leading learners with confirmatory questions to demonstrate how the new formula worked.

To ensure mastery of use of the formulae, the teacher provided several examples. As a way of allowing learners to practise the performance of demonstrated procedure, learners were given an activity from the textbook. It was during these activities that Nthabi would move between groups marking and probing learners to help them do the correct calculations. Each discussion on a concept, ended with learners working on the problem-set as a way of evaluating their ability to perform the taught procedures. These practices formed a sequence of stages of direct instructional approach which the new curriculum pointed as non-examples of active instructional approach and learner-autonomy.

In Nthabi's interview responses, there were traces of direct instructional approach. In response to questions of the teaching methods she used in Grade 8, she said that she used demonstration and her purpose of walking between groups was to explain to learners so that they could do the

right things. Problem-solving is one of the teaching approaches prescribed by the new curriculum and is one of the Mensuration skills expected to be developed in learners under the auspices of the new curriculum. However, problem-solving never reflected in Nthabi's teaching as a teaching approach. Learners were not taught through problem-solving; instead they were taught for problem-solving which occurred as a platform for practising the use of taught procedures/formula. In addition, besides the teaching approaches discussed above, and the issue of learners' use of their home language, Nthabi mentioned the use of games as one way to maximise learning while learners enjoy freedom. However, this was never observed in her lessons including the use of practical concrete materials mentioned in her responses.

The classroom interactions in Nthabi's class were driven by the teacher's link-making incidents where seven links were made to elucidate the explanations. These were link-making:

- to support knowledge building: making links between modes of representation (definition and computational procedure of Perimeter)
- to support knowledge building - making link between scientific concepts (Concept of Length and Concept of Perimeter through their units of measure)
- to support knowledge building - making links between two scientific concepts (properties of a polygon and computational procedure for Perimeter)
- to support knowledge building - making links between modes of representation (the add-all-sides, and multiply-by-number-of-sides computational procedures)
- to support knowledge building – making links between modes of representation of concept of Area (the verbal representation, definition, and the algebraic representation, the formula)
- to support knowledge building – making links between scientific explanations (explanation of Perimeter as it applies to drawn polygons in classroom) and real-world phenomena (Perimeter as applying to real-life objects)
- to support knowledge building – making links between scientific explanations (explanation of Perimeter as it applies to polygons drawn in classroom board) and real-world phenomena (total length of fence around the farm yard).

Throughout the chapter, a total of 26 incidents were analysed as situations where communicative approach was used. The teacher used non-interactive/authoritative communicative approach in three incidents; interactive/authoritative communicative approach in 16 incidents; and interactive/dialogic communicative approach in two incidents.

6.5. Conclusion

In her teaching of Perimeter, Nthabi involved a series of questions towards learners. These questions showed an attempt to actively engage her learners in their learning process. Some of the questions demanded learners' thinking or suggestions on the definition and computational procedure for the concept of Perimeter. The active nature of this part of the lesson was however soon adjusted into actions of direct instructional approach. These were actions such as: teacher repeating, correcting and further elaborating on learners' responses to make final narratives; giving examples and repeatedly reminding learners the definition and computational procedure in order for them to be able to work on the example and come up with correct responses; and didactically working through the examples while guiding learners with leading and confirmatory questions throughout the computation process.

The direct instructional approach in Nthabi's classroom was further exemplified by the teacher's demonstration of the taught computational procedure through a series of worked-examples. Though learners were involved in such examples through a probe over an arithmetic process, they could be said to have been participating in a ritual performance since they were not working independently, and the teacher-led interaction was much more authoritative.

Similarly, the teaching on the concept of Area was guided by an authoritative probe on the definition of Area and the teacher's repeat-and-expand approval. This was followed by the teacher's explanations on the formulae used to calculate Area of different types of polygon. The lesson therefore was mostly a unidirectional presentation by the teacher. The learners only participated superficially by leading and confirmatory questions on arithmetic processes on the taught formulae. The teaching therefore involved dominantly direct instructional approach. The learners' activity was meant for practice and perfection of the use of the taught formulae and arithmetic processes. Nthabi's classroom environment could therefore be said to have very limited opportunities for learners' autonomy in their learning.

The instructional environment in Nthabi's class involved dominantly ritual routines on both the teacher and the learners' sides. The classroom discourses were mostly disobjectified, which made them less formal or mathematical. This characteristic of the classroom discourse thus further confirmed the teaching-learning routines to be mostly rituals. Further, the ritual nature of the classroom routines somehow negatively influenced the learners' competence in the

comprehension of the concepts, especially in problem-solving tasks. These constructs therefore add to the contention that, overall, the classroom environment did not provide much opportunity for learner-autonomy.

In trying to help learners to conceptualise the two concepts, Perimeter and Area, teacher Nthabi made a few pedagogical links during her explanations. To be exact, in her interactions with learners, the teacher made seven pedagogical links, all of which are links to support knowledge building. As summarised in Section 6.4 above, the majority of these links were provided by the teacher herself during her explanations. It was only in one incident in Episode 5 where learners were probed exploratively to make the link by themselves. This was the case where Nthabi led learners into connecting what they had been learning and practising on Perimeter, to the real objects hence their link-making to support knowledge building: making links between scientific explanations and real-world phenomena.

Overall, the teacher-learner interactions mostly involved interactive/authoritative communicative approach. It must be understood that the cases where the classroom interactions were driven by non-interactive/authoritative and interactive/authoritative communicative approaches were situations where the teacher took charge, elaborated some concept, led learners throughout an arithmetic process or identification of sides of the polygon. On the other hand, in the cases where interactive/dialogic approach was used, one conversation was led by the teacher to help learners explain their used computational procedure, while the other was where learners themselves were interacting among themselves to read, interpret and find appropriate computational procedure to solve the given problem.

In conclusion, Nthabi's classroom environment could be described as dominated by teaching-learning practices which could compromise opportunities for learners to operate autonomously. This contention could be corroborated from the analysed dominance of the use of direct instructional approach; ritualised teaching routines and learning rituals; dominant use of disobjectified colloquial discourses; pedagogical link-making executed solely by the teacher; and dominant use of non-interactive/authoritative, and interactive/authoritative communicative approaches.

Chapter 7: Data Presentation and Analysis 2 – The Case of Teko's Class

7.1. Teko's Instructional Practices

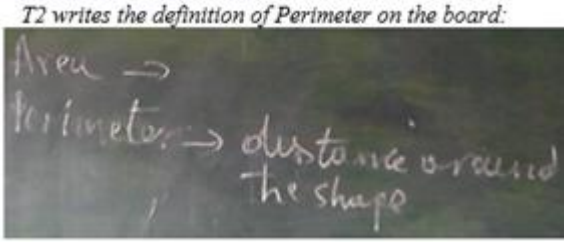
This section presents teacher Teko's instructional practices as observed from his classroom teaching. These are presented in two episodes which are titled according to the teaching activity observed. The classroom environment created and monitored by the teacher is described by the diversity (or lack thereof) of instructional approaches, types of discourses and routines, and interactions involved in teaching the concept. In each episode, the data is first presented as extracts from classroom discussions, as it sequentially occurred in each lesson, followed by the analysis.

7.1.1 (Episode 1; Lesson 1) Review of the Concept of Perimeter for Different Types of 2-D Shapes

Mr Teko began his lesson by telling the learners that the lesson's objective was the study of Perimeter and Area, and wrote this on the classroom board. The announcement was accompanied by the teacher's uttered supposition that the two concepts were studied at primary level, to which learners admitted. The lesson therefore was to be a review of the concepts previously learned, hence driven by examples and problem-set discussions. To attract learners' participation in the review process, the teacher probed the class into defining the two concepts with the initial focus on Perimeter. To this probe, the learners responded with some hesitation, which indicated that even though they were familiar with the concept of Perimeter, they had somehow forgotten which definition suited which concept between Perimeter and Area. However, the responding learners eventually came up with an accurate definition of Perimeter. To make the presentation more engaging and allowing learners to elaborate on the meaning of the definition of Perimeter (as 'the distance around the shape'), Teko asked them what it meant to say distance around the shape (see the extract below).

01: T2: So in today's lesson we are going to learn about Area and Perimeter. *[T2 writes on the board: "Area" and "Perimeter"]* And I want to believe that you learned about these two concepts when you were in primary

T2 writes the definition of Perimeter on the board:



02: Learners: Yes, sir

03: T2: So can anyone of you tell us about these two concepts? Yes, what is Area? *[Selects a learner (Thabo)]*

04: Thabo: Area is the distance around. No Perimeter is the distance around the shape.
05: T2: …So you're saying it is distance, around a shape?
06: Thabo: Yes, sir…Area is the... space.
07: T2: Let's now concentrate on Perimeter. What do we understand if we say distance around the shape?

The beginning of this discussion on the lesson's objective took a more direct instructional approach since the teacher directly informed learners of the concepts to be discussed and uttered a supposition that the concepts had already been done in previous grades; a process that could have been more active through a probe into existence of such prior knowledge. However, this introductory part of the lesson involved some actions of active instructional approach as it proceeded. These actions were: a probe to seek learners' thinking or prior knowledge on the definitions of Perimeter or Area; and seeking learners' further elaboration on the definition of Perimeter. The latter active action was made explicit by the teacher's question '*What do we understand if we say distance around the shape?*' Learners responded to the teacher's questions by simply retrieving their memorised definition of Perimeter, hence they could be said to be using ritual routines. However, the teacher tried to re-direct their routine by posing the question which demanded their further elaboration on the definition of Perimeter; the answer to which would imply their exploration routines.

The active instructional approach initiative advanced through probing soon changed into a rhetoric that was meant for leading learners to remember and mention the computational procedure for Perimeter. That is, the teacher did not wait for any elaboration from the learners, but instead probed them to provide the computational procedure. In this probe, one of the learners provided the *'Base times Height'* as their suggested formula for Perimeter of a rectangle. This response was ignored by the teacher since it was incorrect, but it showed learners' knowledge on concepts of Mensuration though still not competent regarding which formula matched which concept. The next selected learner provided the most accurate response of *'add-all-sides'*, which was accepted by the teacher. As a result, the session proceeded with the teacher giving an example of a rectangle, hence probing the learners to carry out the calculation of its Perimeter through the just-agreed-on computational procedure. After agreeing on the answer provided by the learners, the teacher closed the discussion on the Perimeter of a rectangle with a detailed explanation on the definition and computational procedure. His presentation and interaction with the learners is presented in the extract below.

08: T2: Let's say we have... A rectangle. *[Says T2 as he draws a rectangle on the board]* let's say our rectangle is 3cm, 2cm. … How do we find the distance around that shape? Yes! *[T2 selects a learner (Tumo) to answer]*

09: Tumo: Sir, it's going to be eh… base times height.
10: T2: The distance around that shape?
11: Thuso: Sir we are going to add those sides…
12: T2: Add them? How do we add them?
13: Thuso: Sir, we are going to say 3 plus 2. Another 3 sir, plus 2. *[T2 writes on the board: "3 + 2 + 3 + 2 ="]*
14: T2: Do we all agree that this is how we are going to get that Perimeter?
15: Learners in a chorus: Yes, sir
16: T2: So this is the distance around the shape. This is how we understand and find the distance around the shape…its Perimeter…
17: Learners in a chorus: Yes, sir

T2's drawing and writings on the board



Though the act of providing and working on an example could be seen as one of the actions of direct instructional approach, in this part of the lesson teacher Teko provided it to stimulate the learners' elaboration on the definition of Perimeter, hence could be regarded as a move towards active instructional approach. The active nature of this review on Perimeter of rectangle was further displayed in actions such as: probing to seek learners' suggestions or prior knowledge on the computational procedure for Perimeter of a rectangle; follow up questioning to confirm a learner's incorrect answer and to make the learner aware of the error; further probe to allow a learner to elaborate and carry out the computational process; and inviting the class confirmation on the accuracy of the computational process suggested. To directly confirm the definition and computational procedure for Perimeter, the teacher made a bold concluding statement on these.

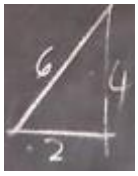
While trying to actively involve learners in this review session, as shown in the extract above, the teacher posed questions which demanded learners to recite the add-all-sides procedure, without probing for their elaboration or reasoning on the accuracy of their response. This therefore rendered the teacher-learner routines as rituals intended to retrieve learners' memorised procedures. The teacher's discourse with the learners addressed the concept of Perimeter as a process of adding all the sides that learners perform to obtain a specific value, thus making discourse personalised and processual hence non-objectified. The latter further indicated their routines as rituals.

While in this introductory part of the lesson, since the teacher posed questions to which learners provided their direct responses, the communication was interactive. However, learners were not given the opportunity to raise own opinions or provide argumentative reasoning to their responses, hence the communication was teacher-authoritative. The teacher's lead on

discussion of the computational procedure for Perimeter of a rectangle was brought in as a connection to the definition of Perimeter just mentioned. This pedagogical link was made explicit by the teacher's question (*'... How do we find the distance around that shape?'*), which had the definition of Perimeter. Therefore, the teacher led a pedagogical link-making to support knowledge building: making links between modes of representation (the definition of Perimeter and the computational procedure for Perimeter), through an interactive/authoritative communicative approach.

The lesson proceeded on the same wavelength with the next step as the probe on the computational procedure for Perimeter of a triangle (as next example) and learners' calculations on the example thereof (shown in the extract below).

> **18: T2:** Okay. Let's take it that this is how we get the Perimeter of the rectangle. What about the Perimeter of... eh, let's say I have a triangle – this is 2, 4, let's say 6. *[T2 draws a triangle on the board, labelling its sides 2, 4 and 6]*
> **19: T2:** What is the Perimeter of that triangle?
> **20: Learner:** Twelve!
> **21: T2:** How do we get the twelve?
> **22: Learner:** Six plus four plus two
> **23: T2**: So that is the distance around the shape.



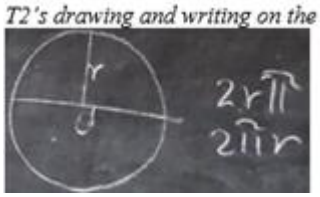
The teacher's use of one more example leaned towards direct instructional approach and ritual routine aimed at demonstrating how the add-all-sides procedure works for different types of shapes, hence allowing the learners to memorise the procedure. The ritual nature of the teacher's probe was attested by his question that demanded the learners to obtain the answer and narrate the procedure they used. This questions did not invite their reasoning on their responses to show understanding of the concept of Perimeter. The learners' responses to the teacher's questions involved mostly the mathematical terms, numbers and operations, hence making their talk to be structured and impersonalised. That means even though the teacher led the class through a partially personalised discourse, learners responded with objectified and more formal discourse. The teacher led an interactive communication since he posed questions which learners were able to respond to with short answers. This however lacked dialogic touch since the learners were not probed to provide reasoning for their chosen responses, thus their communication followed interactive/authoritative communicative approach.

Satisfied by their correct computation process and the final answer on calculation of Perimeter of triangle, the teacher's probe to the learners quickly moved to computational procedure and

an example on Perimeter of the circle. In all these examples, the learners were kept actively engaged by being allowed to come up with the procedure and work on the example to provide the correct answer. Each of these processes however ended with the teacher's detailed summary on the computations and the formula (see extract below).

> **24: T2:** Now what about the Perimeter of let's say a circle? ...Who could find the Perimeter of a circle?
> **25: Thabo:** Sir is pie radius… no.no is two pie radius…. Two, times radius, times pie
> **26: T2:** Two, radius, times pie, so we have two radius pie or we can say two pie radius. That is how you get the distance around this particular shape.

T2's drawing and writing on the board



Once again, the teacher actively engaged the class by posing questions which demanded learners to narrate the computational procedure or formula for Perimeter. This was, however, a further display of ritualised teaching since these learners were not probed or enlightened on the origins of such a formula or on how the formula related to the definition of Perimeter discussed.

In this episode, on the rest of the session on Perimeter of different shapes, triangle and a circle, the learners were kept actively engaged by the teacher's persistent probes in seeking their prior knowledge on the computational procedures and formulae for calculation of those shapes' Perimeter. The discussions mostly involved: probing learners to perform calculations on the example to seek their suggested computational procedure; inviting them to try their computational procedure on a new example, Perimeter of the circle; probe to remind learners about the formula for Perimeter of a circle, and the dimensions/properties of that circle; and probing for learner conclusion on the formula for Perimeter of a circle, then teacher concluding with a straight narrative.

Generally, for this introductory part of the lesson, Teko was observed to be using a variety of teaching approaches each at its different intensities. The act of telling the learners what the objective of the lesson was reflected some of the elements of direct instructional approach. Some of the actions of direct instructional approach included giving a series of examples and concluding each example activity with a detailed explanation of the concept definition and the computational procedure thereof. Given a chance, such concluding details could have been done by the learners to allow a recap on the discussed concept of Perimeter and active engagement of the learners.

Though the lesson on Perimeter seemed a revision activity, a few actions portrayed some elements of active instructional approach. These included: probing learners to seek their thinking or prior knowledge about the definitions of the Perimeter and Area; seeking learners' elaboration on the provided definition of Perimeter; probing to allow and command learners to carry out calculations and provide an answer to each example the teacher provided; inviting the class's confirmation on the accuracy of the computational procedure suggested. The act of probing learners to allow them to elaborate on the meaning of the definition of Perimeter, 'distance around the shape', could be seen as a way to keep them actively engaged, cognitively. However, since they were not given a chance to elaborate, this became a direct instruction activity which only demanded learners to retrieve the previously known definition of Perimeter from memory without any elaboration.

At the beginning of the lesson, teacher Teko made reference to the concepts of Perimeter and Area by making a supposition that learners must have studied the two concepts in their earlier school, at primary school level. This therefore indicated his link-making to promote continuity (to develop the scientific story) at a macro level. The teacher also led learners to move from the definition form of the concept of Perimeter to its computational procedure. This indicated his act of making links between modes of representation (definition and computational procedure).

When proceeding with the lesson, the teacher's probe and explanations were focused on the use of the add-all-sides procedure in calculating the Perimeter of different shapes, triangle and circle, though the circle was given a different special formula. The presentation therefore did not involve any link-making explanation.

From the beginning of the conversation between the teacher and the learners on this review process, there was an exchange of words. This was where the teacher would mostly pose a set of questions as a probe for learners to recite the definition of the concept of Perimeter, suggest its computational procedure and provide a worked answer (and procedure therein) on a given example. The conversation therefore was interactive. Even so, the fact that one learner provided an incorrect response on the definition of Perimeter which was ignored by the teacher who focused on the next learner's correct response, this showed that he wanted to channel the learners towards his desired 'correct' definition. The latter therefore indicated the teacher's

questioning as authoritative. Thus the teacher-learner talk featured an interactive/authoritative communicative approach.

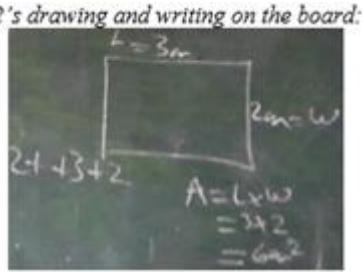
In terms of commognitive properties of his practices in this part of the lesson, it could be argued that Teko had been using ritualised teaching routines. Though learners were given an opportunity to provide the definition and the computational procedure for the concept of Perimeter, they were not probed (or volunteered) to elaborate or reason on the responses they provided. The most important focus was recitation of a memorised definition and computational procedure or formula. The ritual nature of the discussions in this part of the lesson was further attested by the disobjectified nature of the teacher and learners' discourses. In most cases, the talk was personalised (the Perimeter as learner's performed computational process (*use of we*)) and Perimeter was communicated as a process of adding sides of the shape, and had to be an all-class-agreed procedure.

7.1.2 (Episode 2; Lesson 2) Review on Concept of Area for Different Types of Shapes

In the next lesson, after a thorough review on Perimeter of different shapes, Teko proceeded to some review on Areas of different shapes. The lesson on Area began with the teacher's probe on learners' prior knowledge about the computational procedure for the Area of a rectangle. Though some learners mentioned an incorrect naming, '*base times height*', the class and teacher finally agreed on the correct formula, '*Length times Width, or Length by Width*'. To make the review more rigorous, Teko led the learners on the computational process in using the agreed-on formula for the Area of a rectangle as an example (shown in the extract below).

27: T2: How do we find the Area of this... let's say rectangle?
28: Learner in background: Base times height
29: T2: Yes? *[T2 selects a learner (Khotso)]*
30: Khotso: Length times Width
31: T2: Length by Width. If we say this is our length, this is our width…So we are saying Area is equal to?
32: Learners in chorus: "Length times width", "Length by Width"
33: T2: Length by Width, so what is our length here?
34: Learners in a chorus: Three!... times two
35: T2: times two, so our Area is?
36: Learners in a chorus: Six centimetres
37: T2: Six centimetres? [**Background voice**: squared] Oh! Six cm^2

T2's drawing and writing on the board:



As shown in the above extract, the teacher's act of probing learners for the procedure or formula for Area of rectangle did appear as an active instructional approach act, though the learners seemed to already have an idea about the formulae related to concept of Area. This implies that

the focus was not on the development of the concept (conceptual understanding) but rather the retrieval of the formulae from their memories, which therefore implied the teacher's focus on learners' superficial strategies of gaining knowledge. For most of the deliberations in this part of the lesson, the discussion was direct and teacher-led on computational process. This went on with teacher leading on the use of the formula: identifying of sides to substitute for length and width, and multiplication arithmetic process for attaining the correct answer. This therefore implied the teacher's use of direct instructional approach.

In this discussion, the teacher's question, '*How do we find the Area of this... let's say rectangle?* 'indicated his conception of Area as a uniform process that learners had to perform to obtain a specific common value. As a result, the teacher-led discourse for this part of the lesson was processual and personalised hence not objectified and could therefore be considered not strictly mathematical. This thus renders the teacher's routines as rituals. The latter contention is further attested by his questions and the learners' responses which were focused on the rote use of formula, without exploring how it came about, and lack of probe or learners' voluntary argumentative reasoning or elaboration for their answers.

The discussion on this Area of rectangle example was executed through the teacher's questions to which learners provided direct short answers, hence the communication was interactive. Learners had a chance to provide answers which consisted of the formula, the arithmetic processes and the final answer. They were never probed to provide reasoning for their actions or answers or come up with alternative procedures, hence the communication was authoritative, thus, the teacher used interactive/authoritative communicative approach. The teacher also failed to execute any pedagogical link-making process since there was no explanation or question towards learners for definition of Area, how it connects to the shape and formula under discussion.

The lesson proceeded in the same manner, with the teacher probing learners to seek their knowledge on the computational procedure or formula for the Area of a triangle (without an example this time). Satisfied that the learners had mentioned the correct formula for Area of a triangle, the teacher immediately probed learners to seek their knowledge on the formula for Area of a circle. In both of the latter formulae (Area of triangle and Area of circle), though learners were not given a chance to work on the examples, they were the ones providing the

formulae and identified which dimensions of the shape were to be used for the calculations (see the extract below).

38: T2: Now what about the Area of a triangle?
39: Pule: Half times base times height
40: T2: Half, by height…So this is how we get the… Area of a triangle. What about the Area of a circle? How do we get the Area of a circle?
41: Napo: Pie times radius squared.
42: T2: Pie?
43: Napo: Radius squared.
44: T2: Radius squared. This is how we get the Area of… a circle.

The teacher-learner discussion on the two formulae (Area of triangle and Area of circle) could be seen as part of active instructional approach since learners provided the formulae as a response to the teacher's probing questions. However, the discussion was purely a remember-and-mention memory retrieval exercise to check learners' prior knowledge in preparing them to work successfully on the prepared problem-set. This therefore indicated the teacher's use of direct instructional approach. The teacher and the learners' interaction involved ritual routines. That is, the learners were led to mention the formulae without a further probe, to elaborate on the origins of such formulae and provide reasons why such formulae were appropriate. The latter also substantiates the contention on the teacher's use of interactive/authoritative communicative approach as he probed learners to provide these formulae.

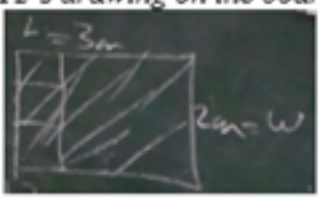
While in this review session on concept of Area, one learner (Tumo) posed a question about the dimensions of a rectangle to be substituted into the formula. The question was specifically about substituting the two parallel sides of a rectangle as the length and the width instead of the two adjacent sides. This question showed that Tumo lacked understanding of the concept of Area and the properties of a rectangle. To address this question, the teacher probed the class to define Area. Learners tried to provide a definition which was directly rejected by the teacher who then provided a more elaborate definition. As a way to explain further and make learners understand the definition of Area, the teacher then introduced the idea of squares in the rectangle to define the Area, hence an example of how to use such idea to find the Area of that rectangle.

Though the teacher's question, '*What do we understand by Area?*' demanded more than just a definition (but elaboration on the definition and some substantiation), the further discussion did not consider the question literally. Instead the teacher's focus was on the accuracy of the definition and computational procedure or formula. However, the computation changed from

the use of the formula to addition of squares and direct use of the diagram. On this presentation, the teacher took a unidirectional instruction to emphasise how the counting-squares procedure works. The following extract shows the teacher's conversation with the learners as he responded to Tumo's question.

45: Tumo: Sir! When we are looking for the Area of our rectangle why don't we multiply the equal sides? We have 3cm on top… we already know that it's going to be 3cm at our base; why don't we say 3cm times 3cm?
46: T2: What are we looking for? …let's go back to define Area. What do we understand by Area?
47: Khotso: The space an object can occupy.

T2's drawing on the board



48: T2: Is it the space? I'd rather say it is the surface, or the region enclosed within set of lines. Therefore, we are looking for the whole region. *[T2 shades the rectangle]*
49: T2: So to find the... we actually want to find how many squares occupy this whole surface. *[T2 draws squares inside the rectangle]* That is basically what we are trying to say. So we are going to count how many squares we have within that region, so that is why we just say 3 by 2. Is that clear?
50: Learners in a chorus: Yes, sir.

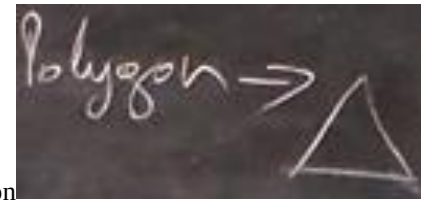
The teacher's act of taking learners back to the definition of Area concept through a probe, showed that he wanted to actively engage them and help Tumo to have a deeper understanding of the concept of Area (since he did not just show how the sides were substituted into the formula). However, the teacher never gave learners the opportunity to correct their response or to bring up one more version of the definition of Area. Instead he resorted to telling them a more detailed definition and further elaboration coupled with a new counting-squares procedure. This therefore indicated the teacher's use of direct instructional approach as a thorough way to prepare learners for the problem-set.

As shown in the above extract, the teacher did some elaboration on the definition of Area as a way to help learners develop a deeper understanding of the concept. To make it more explicit, he introduced a new computational procedure of counting the squares inside the rectangle. By so doing, the teacher made a link between the two modes of representation of the concept of Area (definition and counting-squares computational procedure). Though the learner, Tumo, posed the question as a way of initiating a dialogue with the teacher, the conversation beyond such question was dominated by the teacher's explanation as he developed the link between the two modes. The communication led by the teacher therefore followed an interactive/authoritative communicative approach.

To further prepare his learners for the problem-set session, teacher Teko introduced a regular polygon and hence the Area calculations thereof. The learners were probed into mentioning the

definition of a polygon, followed by the listing of different types of polygons. In one instance in this probe, learners were asked if a circle was a polygon. They responded with a '*No sir'* reasoning that '*it has no sides*'. As correct as the answer and reasoning were, the learners' response was incomplete since they were given an incomplete definition of a polygon (that is, '*A shape with many sides*'). A polygon should be defined with an emphasis on its critical attributes, straight line segments, and many sides. The accurate anti-definition reasoning to circle not being a polygon would therefore include opposites to these critical attributes: it being curved and continuous around the loop. Even so, this inaccurate definition (of polygon) and anti-definition (for a circle) was non-verbally approved by the teacher since they were never challenged. However, the teacher proceeded by providing a conclusion of the discussion while including the accurate definition of a polygon and definition of a regular polygon. The discussion on the polygon ended with a probe for learners to provide examples of regular polygons (see the extract below).

51: T2: One other thing, what is a polygon?
52: Thabo: A shape with many sides.
53: T2: A shape with many sides? Can you give us examples? Just two
54: Thabo: Pentagon and hexagon.
55: T2: Pentagon and Hexagon. What about a triangle? *[T2 draws a triangle on the board]*



56: Thabo: It is still a polygon
57: T2: It is still a polygon… What about a circle?
58: Thabo: It is not a polygon.
59: T2: It is not a polygon? Why?
60: Learners (shout): "No sides", "Because it does not have any sides"
61: T2: So therefore a polygon is any shape that is totally enclosed with straight lines. Then we have regular polygons
– regular polygons are those that... all the sides are equal. Can you give me an example of a regular polygon?
We have different polygons but those that have equal sides and angles are said to be regular.
62: Nku: Square!
63: Tefo: A triangle.

As shown in the above extract, the teacher reviewed the concept of regular polygons through a probe for learners to get actively engaged in the discussion. However, the activity involved some actions of direct and teacher-dominated approach where the teacher provided a more elaborative definition of a polygon and regular polygon. The teacher's act of challenging the learners to explain why a circle is not a polygon indicated his teaching routine as an exploration hence he guided the learners to exploratively engage in the discussion. Since for most of the

time during this discussion the learners exchanged ideas with the teacher in trying to explain the definition of polygon, giving reasons for circle as a no polygon, the communication involved interactive/dialogic communicative approach.

Overall, in this episode, since this was a review on concepts which learners already had some knowledge of, the act of question-answer interaction between the teacher and learners was, in a way, an active instructional approach administered to remind learners about the definition, properties and types of polygons. However, this active nature of the presentation did not last since the teacher provided a summarising explanation on the definition of a polygon and that of a regular polygon. This therefore partly indicated his use of direct instructional approach administered to thoroughly prepare learners for the problem-set.

While on this part of the lesson, Teko's teaching reflected some incidents which could be classified as elements of active instructional approach. These are the cases where the learners were given a chance to take part in the lesson by actions other than just sitting and listening to the teacher. These included incidents where they were asked questions to: provide the computational procedure for Area of rectangle, triangle and that of a circle; provide some calculated answers to the example on Area of rectangle; provide the definition and examples of polygon; and decide and provide the reason why a circle is not a polygon. The latter point, besides, showed that the teacher also wanted to probe learners' use of explorative strategies (elaboration and deeper thinking) as part of their knowledge development.

Some of the teaching activities observed over the episode had some signs of direct instruction. These activities included incidents where the teacher: provided a thorough summary on the formula for Area of a rectangle; provided an example and led learners through the computational process while writing the actual calculation on the board; providing an alternative definition of Area just after learners provided an inaccurate definition; providing explicit explanations, with example, to make clear the concept of Area with introduction of alternative computational procedure (counting the squares inside the shape); providing an explicit summary on the definition of polygon and guiding learners to provide examples of polygons; and providing them with problem-set to evaluate if what had been explained to them had been well memorised.

Furthermore, though at the end of the explanations and examples' discussions there was a session where learners were given a problem-set to work on, the session was meant to evaluate their understanding on the concept just explained. Therefore, Teko could not be considered to have used problem-solving as a teaching strategy.

In the conversations in some parts of the episode**,** the teacher's talk was focused on helping learners retrieve from their memory the formula or computational procedure for Area of a rectangle. This thus included an example in which they were probed to identify the dimensions of the given rectangle to substitute in the formula and the led arithmetic process in finding the correct answer. Therefore, there were no pedagogical links made. Similarly, the question-answer interaction between teacher and learners was focused on reminding them the algebraic formulae for calculation of the Area of a triangle and the Area of a circle, hence no pedagogical links were made, either between the definition of Area and these formulae or between the formulae themselves.

In an attempt to respond to the learner's question on which sides of a rectangle to substitute into the formula as *Length and Width*, teacher Teko reminded the learners of the definition of the concept of Area hence connected it to graphical representation and counting-the-squares procedure. By doing so, he made the link between modes of representation of the concept of Area (that is, link-making to support knowledge building: making links between modes of representation – definition of Area and graphical representation, and counting-the-squares procedure). The conversation in these extracts led nowhere near the link-making process since it was only focused on the introduction of properties and examples of n-sided polygons. The teacher-learner conversation involved an exchange of ideas, including questions and answers on both the teacher's and learners' sides. This therefore indicated that the conversation featured an interactive/dialogic communicative approach. The teacher-learner interactions in this episode therefore involved one link-making incident, one interactive/dialogic communicative approach, and three incidents of interactive/authoritative communicative approach.

In terms of the commognitive properties of the teaching process, most of the actions in Teko's teaching could be argued to be rituals. These included, for example, the teacher's probe to invite learners to mention the formulae for calculation of Area of rectangle, triangle and circle, without any attempt of elaborating on the origins of each formula and how each formula relates to the definition of the concept of Area. The teacher's probe on the computational process in

the example (on Area of rectangle) proved to be a ritual to further make learners memorise or master the use of the formula. The ritual nature of Teko's teaching process was further displayed by the processual and personalised nature of his discourse (that is, disobjectified discourse) towards learners as he explained the use of the formulae and definitions provided. This had one exception where the teacher used explorative teaching routine. This was the scene where he challenged learners to explain why a circle is not a polygon as a way of allowing them to develop deeper understanding of properties of polygons.

7.2 (Episode 3, Lesson 2) Learners' Competence, Classroom Discourses, Routines and Interactions

After the review process on each concept (Perimeter and Area), which was executed to prepare learners for the work on the prepared problem-set, learners began to read the problem scenario so that they could interpret and solve. As they read the scenario, they began arguing on each other's interpretation and hence relation to the discussed concepts of Perimeter and Area. In their arguments, they were predominantly using their home language, Sesotho, but used English when reading the questions. In some instance, during the group discussions, the selected group was already working on the question which demanded their calculation of Perimeter of the given polygon as part of the solution to the problem given in the form of a real-life scenario.

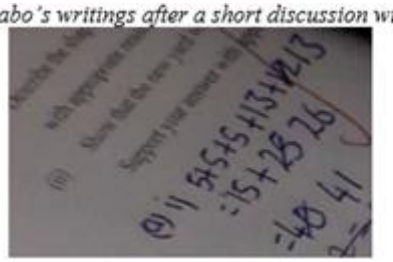
7.2.1 The analysis on learners' observed activities on the problem-set

The group struggled to interpret the scenario and the subsequent question. As he moved around past the group, teacher Teko realised his learners' difficulty to interpret the problem scenario and the first question, or make connections between the scenario and the concept of Perimeter discussed previously. As a result, the teacher stood in front and called the class to attention and interpreted the demands of that part of the problem. After telling the class, that the question needed them to calculate the Perimeter of the given polygon, the teacher went back to the group where members seemed to be struggling. In the group, the he re-emphasised the calculation process to be performed as part of his scaffolding. The group (and all other groups) easily performed their calculations (without much significant discussions) and submitted for marking (which they got the answer and procedure correct hence marked with a tick) (see the extract below).

> *[T2 roams about the classroom to groups, looking over what the learners are doing.] [Tumo reads the question out to his groupmates.]*

64: Tumo: "Where he keeps his animals," Here we are not sure where he keeps his animals. Okay this is where he keeps his sheep. No, hear what they say – they say this part; this triangle we are given is where sheep are kept. "Calculate the total length of the fence required to enclose the part in which Mr Stue keeps his sheep" this means that we have to find this distance…
65: Theko: Hey man see this four… *[T2 moves to the front and addresses the class*]
66: T2: Thank you class, we are only looking for the length where he keeps… the total length where he keeps his… sheep. Not the total length of the yard. [*T2 approaches group Z*]
67: T2: So we are only looking for the length around where he keeps his sheep, which is what we have now. The length around that. How do we find the length around that? The Perimeter of that? [*Says T2 as he points at the shape in the worksheet*]

Thabo's writings after a short discussion with groupmates:



The learners' discussion in their home language indicated their freedom and ability to accurately interpret the problem-scenario and locate parts of the polygon which could relate to the subsequent question thereof. Though they seemed to read, and to some extent, interpret the scenario correctly, they got stuck and the teacher used his direct instructional scaffolds to assist them in making links between learned concept and the pieces of the problem they were reading. The teacher did so by directly telling them that the required length in the question is actually Perimeter of the given polygon. The learners showed that the teacher's scaffold worked, since they were able to calculate and find the correct answer immediately after his intervention.

The learners in this group exchanged words and arguments as they read through and tried to interpret the problem-scenario. They showed considerable collaboration since each was trying to explain and convince the groupmates how they understood the scenario. Their interaction therefore was interactive and dialogic since multiple points of view were heard making this conversation. However, as the teacher realised the learners' difficulty, he tried to assist the class by interpreting the scenario for them and telling the group what they were expected to do to solve the problem. This conversation was one-sided since only the teacher's voice and point of view was heard, thus making the interaction to be non-interactive/authoritative.

After receiving assistance and being marked by the teacher, group members proceeded with their discussions on the question which required them to calculate the total Area of the 12-sided polygon described in the problem-scenario. The group argued on the scenario's interpretation as they tried to make connections between the information in the scenario and the concept of Area just discussed during the teacher's presentations. In their discussion, the group eventually managed to realise the demands of the question, hence they devised an operational plan where

they decided to calculate the Area of a single triangle, from the diagram, and multiply that Area by the 12 which represented 12 triangles for a regular 12-sided polygon. Though the decision was procedurally correct, the groupmates committed a conceptual error in which they used a slanting side (13m) of the triangle as a height instead of the base-perpendicular height (12m). As a result, the group obtained 32.5 as the Area of the triangle which they agreed to multiply by 12 (for 12 triangles forming the regular polygon) obtaining 390 square centimetres. The following extract shows the group's conversation as they worked on the problem.

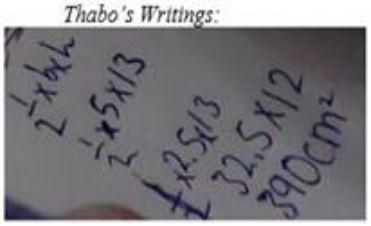
[Learners speaking in their home language Sesotho (Translated to English language)]

68: Tumo: Wait sir! …now we are looking for this Area isn't it, the Area of the whole yard?

69: Thabo: Straight line, there is going to be this thing here, which is going to be equal to this one.

70: Tumo: We have to figure out, the first thing we have to find which is the 12-sided polygon we are talking about, so that we can see what is missing and what is available. Octagon it's eight? Decagon is ten. How much is nonagon? It is nine. Decagon is ten. What is 11 and 12? Sipho! [*Tumo calls out at a learner in another group*]

Thabo's Writtings:



71: Tumo (to Thabo): Did you get 32.5? [*All groupmates look at what Thabo writes*] …Thirty-two point five, which is our Area for here. So we are going to multiply with 12 of this 12 triangles. …we have found Area of the first triangle. So …Let's write it 32.5 times 12! It's 390 meter squared, not centimetre. Sir! [*Tumo calls out at T2*]

The learners' act of using the 12 triangles that make the whole polygon showed that they were, to some extent, competent in interpreting the problem-scenario and relating it to the concept of Area discussed earlier. It also showed that they were competent procedurally and in relation to properties of a regular polygon, since they agreed to find the Area of a single triangle then multiply by 12 which represented 12 triangles corresponding to 12 sides. However, they showed incompetence in relation to the properties of a triangle since they were unable to identify the part of the triangle which could be used as a height. Further, though the group was able to identify the part to calculate the Area of, and accurately devise a working procedure, their workings were a pure computational process which did not show relation to a real-life problem. They could therefore be claimed to lack problem-solving skills.

Learners also showed collaboration when they were discussing. However, not all the groupmates were actively engaged during the deliberations, only Tumo and Thabo were mostly verbal and active in performing the calculations, while the rest of the groupmates were following and copying what the two were saying and writing. These other groupmates could therefore be said to have not been active agents of their learning process at this stage of the lesson. The learners in this group (mostly Thabo and Tumo) took time to brainstorm their ideas

into interpreting the problem and coming up with the accurate computational procedure, which they finally used to get the answer they obtained. Their routines could therefore be said to have been explorations since each tried to reason using their prior knowledge of properties of a regular polygon. The other group members could, on the other hand, be said to be using rituals as their operational routines since they kept quiet, watched and copied what Thabo had written and what Tumo was saying. Though they tried to be explorative in their routines, their talk mostly involved non-mathematical words, and were focused on the process of computation and spoke of the result as an entity of their doing in calculations. Thus, their discourse was mostly colloquial and disobjectified (personalised and processual).

On arrival at the group, teacher Teko realised their mistake and briefly probed and made them aware of their error. In their responses, the groupmates maintained their decision of using the slanting side 13m as the height of the triangle. The teacher tried to probe further to guide them to use the correct height 12. However, first he tried to make them understand what height of a triangle was. Therefore, he provided an example-like analogy of his own height. This he tried to explain by spreading his legs to show learners that the height would be a straight vertical line originating perpendicularly from between his legs, hence trying to make them relate it to the placement of the height and the base of the triangle in discussion. After this analogical comparison and probe, the teacher left the group to make the comparison and decide the height of the triangle as it appeared from the polygon on the question paper (see the extract below).

> **72: T2:** Yes! [*Says T2 as he gets to the group*] what do we have?
> **73: Tumo:** Sir, we first looked for the number of our triangles, then we multiplied by 12, it gave us $390m^2$.
> **74: T2:** What is the height of that triangle?
> **75: Tumo:** 13 meters
> **76: T2:** What about that 12? What can you say about the 12?
> **77: Tumo:** The 12 is the… is the straight line which is going to give us 90˚, which is 12.
> **78: T2:** What do we call that side? The side the height. What is my height? Even if I do this what would be my height? [*T2 spreads his legs apart while standing up, right*.] Are you going to make me to do this? [*T2 slightly bends on one side*] What do you want to be my height?
> **79: Tumo:** From the middle to… *[He points upwards]*
> **80: T2:** So what is the height of that triangle? *[T2 moves away]*

In this discussion, the group persistently insisted on the use of the slanting length of the triangle as the height even after discussing it several times, and this time in the presence of their teacher. This therefore indicated their incompetence in the properties and parts of an isosceles triangle, particularly on how to identify the base and the height to substitute into the formula.

Realising the group's error in identifying the height of the triangle, teacher Teko provided his learners with a scaffolding which was in the form of open questions to which learners had to respond by identifying the correct line in the polygon as the height. Since the teacher never told the group what the height is but rather used an analogy to try to make them compare and come up with the correct height, this teaching routine could be seen as an exploration on the side of the teacher and the learners as well. Since the scaffolding process used an analogy, the conversation could still be regarded as a formal mathematical discourse because the focus was on the parts and measurements of the triangle to be identified as its height.

The conversation between the teacher and the learners in this part of the lesson began with the teacher asking them to narrate the procedure they used to obtain the answer they had written. After the learners had responded accordingly, the teacher provided scaffolding in the form of a probe which was meant to make them realise their error in the choice of the height. This scaffolding also involved a standing-spread-legs analogy by which the teacher intended to show learners that the height is the straight vertical line perpendicular to the base. By doing so, the teacher made a link between the targeted scientific concept, height of triangle, and a familiar analogue, height of the teacher measured or identified from between the spread legs while the teacher was standing. Thus he led learners through a process of link-making to support knowledge building – analogical link-making.

Moreover, since the conversation was through a probe to which learners had to respond accordingly (whether or not they understood their error), the integration was interactive/dialogic communicative approach. That is to say, learners were guided through questions to suggest the naming for the line of 12 metres, and to decide the direction or position of the teacher's height, hence the communication was dialogic, thus indicating the use of interactive/dialogic communicative approach.

After the teacher's scaffold, the group members went back to the diagram and eventually realised that they had to use 12m as the height. However, their realisation emerged from the analogy of spread-legs the teacher had used when explaining and probing to make them realise their mistake and identify the correct dimension to use as height. As they discussed, the learners in this group seemed to deviate from the direction given to them by the teacher (that is, taking height of the triangle as 12m) and hence multiplying the height (12m) by 2 to get 24m, with the understanding (or lack thereof) that for the whole 12-sided polygon, the height should be 2

times the height of the single triangle. This new perspective deviated from their prior decision, that to get the total Area they had to multiply the Area of a single triangle by the total number of triangles in the 12-sided polygon. Due to this new decision, the group used the correct formula for the Area of a triangle (with a height of 24m) getting 60 as their Area. They further argued that the answer, 60, they had obtained was for only one triangle in the polygon. They then agreed to multiply the 60 by 12 (representing 12 triangles making the polygon) getting 720. Their discussion is presented in the following extract.

82: Tumo: Ah, it's 12! Eiza! So, we are still on the right track, it's just because we ought to do the height, which is supposed to be 12.
83: Thabo: Is it going to be 20? We took thirteen…
84: Tumo: No we took 13 by mistake dah. …here they are incomplete. But, do you hear where sir's point is? Sir is coming back and say when I am standing this way, are you going to measure my height from this side or from the middle going up? In order for you to find my height…you are going to come from here. [*pointing between his legs*] isn't it I have spread my legs sir…you are going to come straight up; it is then that you can find my height. But you are coming from this side… you cannot say you will measure my height from this side. Yes! Do you understand? [*Tumo looks into Thabo's workings*]
85: Tumo (to Thabo): So this means that I have to increase with 12… Then I say 13 plus 12
86: Mosa: No! 12 plus 12
87: Tumo: Oho… 12 plus 12 because this one ends there.
88: Thabo: It ends midway…
89: Tumo: It has to end further. So it's 24.
90: Mosa: What are we going to do?
91: Tumo: We are going to say half base times height. Our height is 25m
92: Thabo: 24!
93: Tumo: It gives us 60, 2.5 times 24 it gives us 60. How much did we get that side?
94: Thabo: I found 60
95: Tumo: It is for one triangle. We are going to multiply it with 12. So we are going to say 60 times 12, how much is that? 60 times 12? 720!

Though this group had memorised (and correctly used) the formula for Area of a single triangle, they showed that they still did not have a clear understanding of the concept of Area and the dimensions or parts of a triangle. This therefore indicated their lack of conceptual understanding of the properties of polygons. Though their arithmetic process and the answer were well executed while using the incorrect value for the height of a triangle, they committed a conceptual error by multiplying the 12 by 2 to use it as a height.

Besides the error they committed, the group showed plenty of collaboration as they discussed and executed their plan of using 24 as a height and multiplying 60 by 12, this as their overall engagement in this activity. This collaboration indicated that they deployed an interactive/dialogic communicative approach which could be seen as a positive move towards their deeper conceptual understanding. The group also tried to use 12 as a height after their

teacher's probing, however they used their explorative manipulations to try to come up with the computational procedure which appeared to be the best for them. This implied that they were not only relying on what the teacher had demonstrated to them previously, hence their use of explorations as their learning routines to gain knowledge.

Though the learners' routines proved to be explorative in trying to come up with the correct answer, their talk of the mathematics objects was non-objectified. That is, their talk focused on the process they performed to find the answer, hence their discourse was processual and personalised. This therefore renders their discourse as not fully formal and mathematical.

In his random visits to the groups, Teko arrived at a group once again to check if the plan he had provided to them previously (through probing) worked. Noticing that the group had committed a conceptual error, he probed to help them realise their error and make a correction. In the probe, the groupmates were made to realise that their prior decision of multiplication by 12 was correct though they had to use 12 as a height for the triangle instead of 24. The following extract shows the conversation between the teacher and the group.

96: T2 (to Thabo): Half base by height. Half of five by…
97: Tumo: Twenty-four. Twenty-four sir. Sir isn't it this line, our line ends midway, does not get to the end of our polygon. So which means if it is 12 here, to reach the other side it's another 12, which makes it 24...
98: T2: Then what do we call that distance?
99: Tumo: Ah…remind me… what do we call it? A bit sir … Wait sir which distance?
100: T2: The distance from here to the other side of the polygon…?
101: Tumo: Is the total distance…
102: T2: What if you have this Area? [*T2 points at a triangle which forms part of the polygon*] what if you have this Area? How many of these Areas do we have? Let's just concentrate on these ones; what's the Area of this?
How many of those do we have?
103: Thabo: They are 6, it's 6.
104: T2: Then we have others this side. How many sides do we have?
105: Groupmates: Twelve!
106: T2: So how many of those are we going to have? How many of those small Areas are we going to have?
107: Mosa: Sir we are going to have 12.
108: Tumo: Why twelve?
109: Mosa: Isn't it that here these things are not complete, those triangles are going to be twelve
110: Tumo: Sir says, those like this, how many are we going to have; you are saying 12. Why do you say 12?
[*Mosa explains to Tumo further with reference to teacher's explanation*]

Though his probe did not immediately lead learners to use 12 as a height for a single triangle, the teacher continuously posed open questions which allowed them to deeply think and explore

some properties of a regular polygon (that is, allowing them to use sophisticated and explorative learning strategies). However, the use of the number '12' brought even more confusion to the learners since this time it referred to the number of sides of the polygon or the number of triangles which make that polygon. As a result, this indicated the learners' lack of understanding of properties of regular polygons. Additionally, their discussion never involved any relation to the idea of a yard on the problem-scenario. Hence their actions were focused on identifying the height of the triangle and the arithmetic processes to be followed. This therefore indicated the learners' lack of problem-solving skills. The teacher-learner communication in this discussion involved interactive/dialogic communicative approach since both the learners and the teacher had equal share in the talking and the learners were allowed to raise their opinions and reason for their taken decisions.

Once again, the teacher approached the group and persistently probed them to show that they had made a mistake by using 24 instead of 12. Eventually the group used 12 correctly as the height of the triangle and correctly multiplied by 12 sides, getting 360. This final answer satisfied the teacher hence he marked their work with a tick without any further discussions (see the extract below).

> **111: T2 (to group Z):** So how many of …. How many triangles?
> **112: Members:** Twelve! Twelve triangles.
> **113: T2:** So what is the Area of each triangle?
> **114: Mosa:** Two point five times 12.
> **115: T2:** So what is the total Area of all triangles?
> **116: Tumo:** Three hundred and sixty meter squared.
> **117: T2:** How do you get 360? [*Thabo tries to explain from his workings how they got 360*]
> **118: Tumo:** It must be thirty, yes, thirty… this 12 is our height it cannot be 24 because 24 is for 2, this is our height.
> **119: Thabo:** It will be 5 times 6.
> **120: Tumo:** What are you doing? 6 or 12?
> **121: Mosa (to Thabo):** Man, isn't it that we are using this 12? [*T2 ticks Mosa's work*] *[Teacher marks with a tick on Thabo's paper without further discussions]*

In this part of the discussion, the teacher's active scaffolding enabled the learners to be explorative, realise their errors and come up with the correct computational procedure and final answer. The learners' competence could therefore be said to have been realigned, enabling them accurate use of explanations, queries and elaborations towards their decisions which were followed by their computational processes. They also showed considerable collaboration and engaged their teacher as they went through the discussions and realization process.

Throughout the visits he made to the group, teacher Teko provided scaffolding in the form of questions and brief explanations with the aim of making the learners to realise their errors and hence make corrections. Most of the talking was done by the learners in responding to the teacher's questions and making new suggestions on what line represented the height and deciding on what to do with it to work towards the correct answer. The communication among the learners and between the teacher and learners therefore featured an interactive/dialogic communicative approach, and was only focused on the choice of a line in the polygon. This could be substituted in the formula as the height of the triangle, there were no incidents where neither learners nor the teacher attempted to make any pedagogical links.

In the beginning moments of their work on the problem-set, the groupmates in group Z tried to read together and interpret the questions on the problem-set. They however failed to make appropriate connections and ended up taking every detail of the teacher's explanation to answer the questions without any attempt to reason for their decisions or ask questions to show their level of understanding or ask for elaboration. These routines therefore showed the ritual nature of the learners' routines in this group. Since their discussions were in their home language, Sesotho, more often the learners got involved in out-of-concept discussions hence their discourses were a mixture of informal and colloquial discourses.

Though the group Z members tried some elaborations on the decision they made as their computational procedure, they did not provide adequate conceptual reasoning to support their choices and their discourse did not include any relation of the definition of Area concept to the problem at hand. Therefore, their operational routines at this stage were not totally explorative yet not purely rituals. One element of their discourse that could qualify their routines as rituals was the disobjectified nature of their discourses. That is, the group talked of the concept of Area of the given polygon as a process (processual discourse) of multiplying half by five by thirteen then multiplying the answer by twelve, and their talk implied that the procedure or the concept of Area they were working towards was the product of their processual performance (personalised discourse).

While working on the problem on Area of the whole polygon, the learners were observed to be more explorative in their routines. Besides being incorrect, in trying to obtain the height of a triangle (or the polygon), they brainstormed and deeply discussed their procedure hence found some reasoning which related to how the triangle related to the whole polygon, which implies

that they had to explore properties of regular polygon in order to decide on multiplying by 12. This therefore indicated their explorative routine. Even so, their discourse was continuously personalised and processual. Though in most cases the learners' discourse (including the teacher's) were disobjectified (that is, personalised yet partially structured), the learner's routines in this part of the lesson were mostly explorative. That is, their decisions were substantiated by their prior knowledge (or lack thereof) on properties and referring to the previous discussions.

7.3. Teko's responses to the Interview Questions - Teacher's understanding of his role

This section presents Teko's responses to the interview questions. The presentation includes the analysis on how these responses convey his understanding of the expectations of the curriculum and his role as a teacher in a learner-autonomous and active-learner-based mathematics classroom. In the extracts presented, Teko responded to seven main questions accompanied by some follow-up questions intended to seek clarity and further information. Each extract presents mainly the teacher's response to the posed question and, in some instances, responses to follow-up questions.

7.3.1. Question 1: How do you feel about the new integrated curriculum, and what are its main expectations, especially on the teaching strategies and learner's classroom behaviour and how do those compare with the old curricula expectations?

> **Teko:** *... you know; I think this is what we need. ...you can see that...what kind of people we have those who are able to interact with them more than… Most of the time we were just told. The current kids will end up not listening to you if you just tell them.*
> *...that interaction, makes students to be… those who can be independent or autonomous. Let me take learners; our learner will be able to be autonomous, but when it comes to our side ... a lot of interaction makes us to have a slow progress, ...I have seen that it has that impact of making us slow because we have to see that they are fully involved. So it makes you to be slower than when you were just telling them and they listen then you can just continue, that would make us to move better.*

In response to the question of how he sees the new curriculum, Teko insisted that the curriculum is exactly what the country needs since the types of learners who exist in schools are more interactive. He attested that the interactive nature of the types of learners makes them academically self-reliant. In comparing the new curriculum to the old one, teacher Teko showed that in the old curriculum learners were just told everything they needed to be taught, while the existing learners easily lose concentration if the teaching is too direct and characterised by telling. He however believed that the learners' excessive interaction and active

nature of their classroom practices make his teaching to be slow since they consume a lot of time, and indicated that the lesson would go faster if the teacher was the one telling and presenting to the class and they just participate mostly by listening. This therefore indicates that he preferred a more direct instructional approach against the active nature of the present learners.

7.3.2. Question 2: What do you understand by active learning and teaching, and learner-autonomy in a mathematics classroom, and what role do you play in order to facilitate active learning in your mathematics classroom?

> **Teko:** *I think they need you to describe them first so that I can... Yes, if you give a brief definition.*
> *... This one of allowing them to be independent ...it can work, a lot. I think this is what can help us a lot...and that of being actively involved but still being.... I think if they both work, that's what can work well for us. There, the role of a teacher I think is just to check if they are achieving things that he is expecting. His main role is to evaluate. He should check whether when we... when all these things are happening, the objectives are met.*

To this question, teacher Teko showed unfamiliarity with the two terms, active learning and learner-autonomy. However, after the researcher's hints, Teko remarked that the two terms were useful tools in a mathematics classroom. He then indicated his role as that of monitoring the learners' progress and evaluating their work; whether they successfully complete the given activities. This therefore described his role as a supervisor and an evaluator, as a rather authoritative position in the teaching and learning process.

7.3.3. Question 3: With your definition of learner-autonomy and active instructional approach to teaching and learning, how do you teach Mensuration to help your students comprehend the topic thoroughly?

> **Teko:** *Group works, they work better because if they don't understand, they can understand the classmates and the presentations. They present the concepts to each other ... it also, I think it increases their activeness because they don't know who the teacher is going to choose, and everybody wants to be ready. They come prepared, always, so she doesn't want to be clueless in can she is selected, then she would just stand up and cries in front of everybody... Everybody always comes prepared to class.*

To promote learner-autonomy and active learning, Teko described his teaching strategy as group work, class presentations and learners' prior preparation on the concept to be discussed in class. This indicated utterance of active and collaborative classroom preference.

7.3.4. Question 4 (a): In a learner-autonomous mathematics classroom, how do you approach different learning styles?

> **Teko:** *I think there it means we have to give them things like … a sort of a research meaning it's … for example, I may just look at what I have to do this week, then I tell them that this next week we are going to do this topic this way and that way. So then they come back and tell me that there we found that it's like this like that … I'll be guiding them there and there. Just something like a mini research … they still need that much guidance…maybe when we come to class then it becomes something like a mere discussion. Meaning each one will find these things by themselves or in their own ways, so that if we're in class, those different life styles, each one comes up with their own ways, mine is just to help them to achieve the same learning goal.*
>
> *These struggling ones you know it's just to give yourself time mostly… that says that one too must go with sacrifices from the teacher's side. Then the teacher will have that thing that says when we're here, these ones who are struggling I should have time for them so that they don't go with the same pace as those others, they might even lag behind too. So I think that …actually if we could take this one of active and being independent, those who… It's still where the teacher is supposed to be involved mostly on those ones. Those who are able to do things on their own, I'll be guiding them. These ones whom you have to pay more attention to them, and have more time with them… that's where even in weekends you can say no these ones who have difficulty must come so that we look into how we can proceed with the class work.*

To cater for the learners' different learning styles, Teko mentioned a series of teaching-learning activities. These were: giving learners research tasks prior to the lesson to accommodate different learning styles; teacher tells learners the objectives of the coming lesson in advance and learners do some investigation on it and submit later; providing guide persistently; after research prior to the lesson, learners and teacher conduct a discussion as instructional method; each learner finds out things by themselves in a way that suits them individually and in a way that each understands the phenomena; prior lesson assignment makes learners to be creative and come up with their own way of doing things; helping learners of different learning styles to achieve the same lesson goal; teacher doing much to help learners to understand; teacher provides limited guide to those who understand and push themselves while creating more time for those who struggle to understand the content, even during the weekends. Most of these activities indicated the teacher's utterance of active participation for learners, especially for those who understand quicker or are able to learn better on their own, while for those who struggle and are unable to learn better on their own the teacher provides more direct teaching using extra time.

7.3.5. Question 4 (b): In a learner-autonomous mathematics classroom, how would/do you encourage your students to express their creativity, and maximise participation?

> **Teko:** *I think I would, I could do projects with them, they could do projects…Well the teaching aids could be important….*

To create a more practical environment and allow learners' creativity, Teko suggested learners' individual and group-guided projects, and use of teaching aids. The first idea could be related to some active participation, while the idea of teaching aids works better with a teacher-reliant presentation method hence could be related to direct and teacher-reliant approaches.

7.3.6. Question 5: What classroom practices do you think mathematics teachers should master in order to promote learner-autonomy and facilitate active learning to maximise learner conceptual understanding?

> **Teko:** *… I am expecting to see my new teacher… interacting much with his students, intervening there and there… things which maybe … for example if we have formed groups, he should visit each group to make sure that they are progressing. Then, maybe sometimes, he should walk to the board, to…. He should talk about general things which are deferring issues in the groups, to say no, I am seeing this and this, how do you think we can approach it? Maybe others should come up and say no.., we think this issue will be addressed properly if it was like this and this. So, for me, when we are talking about the teacher, what type of the teacher should he be? …actually the one that allows students to come up with ideas, so that he can just direct them to the right path or facilitate their work.*

For promotion of learner-autonomy and facilitation of active learning, Teko suggested a number of instructional practices. He recommended that teacher should interact with learners in each individual group to monitor their progress when given some group task to do, and upon realising common mistakes/issues in the groups, the teacher should walk to the board to explain and guide learners to understand or deal with the issue through some thorough explanations. He further suggested that the teacher's major role should be to allow learners to suggest solutions and procedures to solve a class-common issue, and provide them with a guide to do the correct procedures and routines. The idea of engaging each learner-group and monitoring their particular activities indicated use of active instruction. The idea of addressing learners' common difficulties by directly explaining to the whole class in a presentation manner indicated a rather direct instructional approach. Teacher Teko however, provided some activities which indicated a provision of active and autonomous learner practices. These were

actions such as giving them the opportunity to suggest computational procedures and solution approach for some real problems.

7.3.7. Question 6: How do you feel about the way you conducted the lessons, and to what extent do you think the learners were autonomous and actively involved in the learning processes?

> **Teko:** *... it didn't go the way I was expecting. ...personally I realised that I didn't prepare enough in the sense that, when teaching that topic, there should be a teaching aids that you bring to class. So that when you talk about something… for example when we talk about Area, so that you show student something then he can see it in different ways… that it is different form when I was just talking of how it could be….*
> *-They were trying to be independent but you could realise that they still needed me to check on them and often to explain. Because, truly I realised that it was only few groups that were able to get to where we wanted them, the rest it was a bit difficult.*
> *... I think the big role that I played, like I said, this content of Area, I have not yet done it at all. I think it was the issue of ... I think a brief introduction that one I did make…it made them to relax and realise that, because I did the easy ones of rectangle, triangle and then circle… then from there, they were the ones who did the rest and they realised how all was to be done….*

In response to the lesson-reflection part of the interview, Teko evaluated his lesson as unsuccessful due to under planning and lack of use of teaching aids. He elaborated that learners understand better when using teaching aids while explaining. This indicated his belief in direct instructional approach. He reported on his learners' incompetence in terms of lack of understanding during problem-set activity and their dependence on the teacher's explanations and interventions during activities. He also indicated that only a few learners showed persistence to achieve the lesson goals and a few of them were able to interpret and solve the problems given to them. He further insisted that most learners were only able to perform operations and exercises using what was discussed with him during presentations in that lesson. These ideas indicate that Teko considered his learners as incompetent in terms of problem-solving, and that though they were actively engaged throughout, most did not show persistence and confidence, and they relied on memorised procedures. Teacher Teko hinted at his role as providing the learners with the introduction of concepts in sequence, which implied that he believed in more direct instructional approach.

7.3.8. Question 7: What do you think was your role in this classroom during this lesson, and what was learners' role, and what improvements would you do in your teaching approach to maximise active learning, promote learner autonomy and conceptual understanding?

> **Teko:** *Yah…of course, in the next class, I need to have certain teaching aids so that I present them in a way that they are very clear. That presentation could be better than that one of my introduction which didn't have them… so I really think if I can be asked to go and teach the same thing again, the first thing that I would do is that one of …of having teaching aids so that when I am talking to them, saying when we talk of Area we are talking about this thing, when talking of Perimeter then we circulate around this object , so that we see that when we talk of this distance around this shape to them we're talking about what….*

In response to the question of future improvements on his lessons, Teko suggested that using teaching aids to explain and present concepts was far better than just using the introduction without anything to show to the learners. This showed that the teacher believed in a teaching situation which is mostly characterised by the teacher's explanations and demonstrations, which would benefit significantly from the use of teaching aids and visuals. This therefore indicated his preference and belief in direct teacher-led instructional approach.

7.4. Teko's Data Consolidation - Interview Responses Vs Observed Actions

As discussed in ***Episode 1***, Teko's teaching involved a number of incidents which marked it as direct instructional approach. These included telling and giving a series of examples and concluding each example activity with a detailed explanation of the concept definition and the computational procedure thereof. The direct instructional approach was visible also in the review session on Area. Here the teacher provided: a thorough summary on the formula for Area of a rectangle; an example and led learners through the computational process while writing the actual calculations on the board; an alternative definition of Area just after learners provided an inaccurate definition; explicit explanations, with example, to clarify r the concept of Area; an introduction of alternative computational procedure (counting the squares); and a summary on the definition of polygon and leading learners to provide examples of polygons.

These observed classroom actions, to some extent, conform to the teaching practices indicated by Teko in his interview responses. The responses somehow provide some substantiation to his dominant use of direct instructional approach. Teko suggested – and was observed – allowing some group discussions which promoted a few interactions which could allow sharing of ideas. However, in his responses during the interview session, he cited some disadvantages of that learner-learner interaction including time consumption and the need for considerable guidance by the teacher, hence it would be much better if he could just tell them everything while they simply listen attentively. He insisted that even when the learners are given a task which they

have to do independently, his role is still to regularly provide guidance for accurate completion of the task.
He further insisted that if he were to observe another teacher, teaching to promote learner-autonomy and active learning, he would expect that even if discussions were allowed, more often the teacher should take control, stand in front and explicitly explain what is expected.

In reflecting on his lesson, Teko showed his dissatisfaction in the way the lesson unfolded, blaming his under preparation due to lack of teaching aids. To show that he preferred direct instructional approach, he emphasised the importance of teaching aids in teaching the topic of Mensuration. He also insisted that learners were not that independent since they still needed much of his intervention, especially during their problem-set activity. This could therefore be the reason for a more authoritative intervention observed.

In addition to the learners' limited independence, which therefore led to his direct instructional approach, Teko described his role in that lesson as providing an introduction on the concept with examples on different shapes, so that the learners could follow and emulate the introductory examples to carry out the problem-set activity. To add to this uttered role, and in response to the question of improving his teaching, he insisted on the use of teaching aids during his introductory presentation and cited their effectiveness during such presentations.

These interview responses, in concurrence with observed practices, indicate that Teko considered direct instructional approach as effective and appropriate for teaching the Mensuration concepts. I therefore argue that this perspective, however, allows very little (if any at all) learner-autonomy as suggested by the curriculum. On the other hand, Teko's teaching involved some incidents which contributed to active instructional approach. These included: probing learners to seek their thinking or prior knowledge about the definitions of the Perimeter and Area; seeking learners' elaboration on the provided definition of Perimeter; probing to allow and command learners to carry out calculations and provide an answer to each provided example; inviting the class confirmation on the accuracy of the computational procedure suggested.

In a similar manner, Teko's responses during the interview session hinted at teaching practices adopting active instructional approach. For instance, he insisted that learner-autonomy and active learning are important for knowledge development at Grade 8 level. In response to how he would approach the idea of different learning styles while maintaining active instructional approach and promoting learner-autonomy, Teko suggested a pre-lesson research by learners and then reporting back according to how each understands the concept. However, this was never observed since the observation was limited to classroom practices during the teaching of the two concepts (Area and Perimeter).

Furthermore, in response to what practices he considered appropriate for a mathematics teacher, which could ensure active instructional approach and maintain LA, Teko suggested that the teacher should allow learners to interact and provide suggestions on how the learning process could be conducted and the teacher should support their ideas. These suggested practices were partially observed in Teko's teaching. As discussed in all the episodes, he was observed moving around from group to group to monitor learners' progress on the given task. However, learners were not observed providing suggestions for their knowledge development strategies. To confirm this approach even further, Teko made a number of suggestions during the interview session. For instance, in response to what the role of a mathematics teacher should be in a classroom which practises active instructional approach and LA, he suggested that the teacher should monitor the learners' progress and their work towards achievement of the objectives.

Furthermore, in response to how he could adjust his teaching approach to accommodate the struggling learners, Teko suggested provision of extra time for such learners to help them catch up with the rest of the class. However, this could not be observed since the observation was limited to classroom activities during the lesson time only.

Teko's description of his learners as interactive indicated that he considered them to be participating in their knowledge development by collaborative interaction with each other and with the teacher. He further insisted on how important the learners' interaction was as their role in response to curricula expectations. He showed that the learners' interactions allowed them to be more independent and confident during the learning process. This response somehow indicated that Teko perceived the learners' collaborative interactions, among themselves and with their teacher, to have created more opportunities for their learning autonomy.

In response to the reflective question on how he perceived his learners' competence (during the lesson) in terms of their active learning and learning autonomy, he insisted that his learners were trying to be active and independent but failed hence needed the teacher to frequently explain and help them carry out accurate computations. This response shows that Teko considered his learners dependent on his explanations and hence relied on the memorisation of processes and the teacher's explained computations. It further indicated that he perceived learners' lack of confidence and endurance to get to the correct solutions.

Moreover, the responses from Teko's interview showed little realisation of the learners' competence with respect to the concepts under discussion. He complained that his lessons did not go as well as he expected since the learners could not interpret and answer the questions with ease, hence blaming his under preparation for the lesson. This indicated that he perceived his learners as incompetent in attempting and working on the problem-set accordingly.

To further insist on his learners' incompetence, he explained that even after the observed lesson, he had to remain behind to show the learners practically by using some mathematical tools to make them understand the question and provide correct computations on the problem-set. This response corresponds well with the learners' classroom practice that was observed during each lesson where most learner groups were not able to interpret the problem-scenario and produce appropriate computations. This could therefore be argued and linked to the type of teaching they received prior to the given problem-set since the lesson seemed like a review of the concepts previously discussed.

7.5. Conclusion

In his lesson on Perimeter, Teko displayed a number of teaching actions which conveyed his characteristic instructional approaches. Since the lesson on Perimeter was a review on learners' prior knowledge on the concept, a number of actions involved teacher-learner question-answer discussion which kept learners actively engaged by responding to and discussing the teacher's questions. However, the teacher often intervened when learners showed lack of memory of definition of the concept, properties of polygons and computational procedure or formula, thus resorting to actions of direct instructional approach. These actions included: providing the definition; elucidating the definition by giving an example of computational procedure; telling

learners the required properties of the polygon in an example; and giving out the appropriate procedure for calculation of Perimeter of such polygon.

Similarly, the lesson on the concept of Area was conducted as a review on the definition, computational procedure and formulae for different polygons, and properties of such polygons. Teko's teaching on the concept of Area reflected some incidents which could classify as active instructional approach. These were incidents where the learners were given a chance to take part in the lesson by actions other than just sitting and listening to the teacher. These included incidents where they were asked questions to: provide the computational procedure for Area of rectangle, triangle and that of a circle; provide some calculated answers to the example on the Area of rectangle; provide the definition and examples of polygons; and determine and provide a justification for why a circle cannot be classified as a polygon.

Some of the teaching activities observed had indications of direct instructional approach. They included incidents where the teacher provided: a thorough summary on the formula for Area of a rectangle; an example and led learners through the computational process while writing the actual calculations on the board; an alternative definition of Area as correction to learners' inaccurate definition; explicit explanations, with example, to clarify the concept of Area with introduction of alternative computational procedure; an explicit summary on the definition of polygon and leading learners to provide examples of polygons; learners with problem-set to evaluate if what had been explained to them had been well memorised.

Further, though at the end of the explanations and examples' discussions there was a session where learners were given a problem-set to work on, the session was meant to evaluate their understanding on the concept just explained. Therefore, Teko could not be considered to have used problem-solving as a teaching strategy; rather, he was observed to have been teaching his learners to prepare them for the problem-set activity.

During the two review sessions, on Perimeter and Area, the teacher's routines were mostly rituals, except in rare cases where he became a bit explorative and asked a group of learners to elaborate and provide some reasoning for the definition of Area as a way to help them understand the correct procedure. The ritual nature of Teko's routines was further reflected by his disobjectified discourses and persistence in leading learners' rote use of the formulae for Area of different polygons.

During the session on problem-set, the group members mostly repeatedly read the problem-scenario and brainstormed on the possible interpretations, hence tried to come up with computational procedures for the problems. They did not show much reliance on the teacher's definitions, elaborations and given procedures, thus somehow their routines were explorations. While on the problem-set activity (specifically on Area of polygon), the group managed to interpret the scenario and devised an accurate plan on solving the problem to find the correct answer. Their plan, which they managed to execute, was to calculate the Area of a single triangle then multiply their answer by the total number of sides (12). Though the plan was correct and their routines were a bit explorative, the group committed a conceptual error in which they used the incorrect side of the triangle as its height. This indicated their incompetence in relation to the properties of polygons.

The learners in the group also showed some incompetence when working on a problem that required them to calculate the Perimeter of the given polygon. They could not identify the correct dimensions of the polygon to substitute into the formula, hence performed incorrect calculations, even though they correctly used the formula and procedure, and the arithmetical process. Due to the direct nature of the teacher's scaffolds, every time – following his intervention – the learners were able to carry out the correct procedures using his advice as it was. Even so, all the calculations were performed with the aim of using the formulae learned but not to write up the solution which related to the way the problem was structured, hence the learners could not be said to have mastered the problem-solving skills expected of them.

Generally, in his teaching, Teko made six pedagogical links in presenting some explanations while trying to elucidate the concepts of Perimeter and Area and problems thereof. In five incidents, he performed link-making to support knowledge building (making links between modes of representation (four links), and Analogic link-making (one link)), and in one incident he performed link-making to promote continuity (making links to develop the scientific story at a macro level). In most of these incidents the teacher and learners exchanged in the roles of link-making. Further, throughout the two analysed lessons and group discussions, teacher Teko interacted with learners through six incidents of interactive/dialogic communicative approach, five incidents of interactive/authoritative communicative approach, and one incident of non-interactive/authoritative communicative approach. Based on these two issues, it could be concluded that Teko's instructional environment provided learners with enough opportunities

to participate in their knowledge development processes, thus maximising their chances for learning autonomy.

Teko's responses to the interview questions dominantly suggested that he preferred a classroom environment that is characterised by actions of an active instructional approach. The majority of them indicated that he considered his role as monitoring, supervising, marking for evaluation, and explaining explicitly where learners had difficulty. The latter uttered practices however partially subscribe to his strict authoritative instructional practice. When read together, the observed instructional practices from Teko's class, to some extent, concur with his uttered instructional practices from the interview. However, there exist responses which do not concur with his observed instructional practices. For instance, some of his scaffolding actions were direct while he uttered active actions.

Therefore, viewed in general, Teko's classroom environment partially provided learners opportunities to actively and independently participate in their learning, thus maximising opportunities for their autonomy. The latter conclusive perspective is further substantiated by: the balanced use between the active and direct instructional approaches; the balanced execution of ritual and exploration routines; less informal and more colloquial (and disobjectified) discourses; most instances where learners participated in the link-making process; and more frequent use of interactive/dialogic communicative approach versus less frequent use of interactive/authoritative communicative approach and non-interactive/authoritative communicative approach.

Chapter 8: Data Presentation and Analysis 3 – The Case of Nkoe's Class

8.1. Nkoe's Instructional Practices

This section presents teacher Nkoe's instructional practices as observed from his classroom teaching. These are presented in four episodes titled according to the teaching activity observed. The classroom environment created and monitored by the teacher is described by the diversity of instructional approaches, types of discourses and routines, and interactions involved in teaching the concept. In each episode, the data is first presented as extracts from classroom discussions, as it sequentially occurred in each lesson, followed by the analysis.

8.1.1 (Episode 1; Lesson 1) Teaching Perimeter Through a Fence-Around-Site Analogy

Teacher Nkoe began his lesson by probing learners to remind them about the *'site'* and its 'usual' shape in the context of Lesotho. Learners showed familiarity with the idea of a site since they provided a Sesotho word for it, '*Sets'a*' and they uttered a square or rectangle as the '*usual*' shape for a site. Learners' mentioning of any other shape, such as triangle, stirred other learners since it sounded '*unusual*'. The discussion between the teacher and learners proceeded with a question-and-answer review on the properties of square and rectangle, and the units of length. This review soon revealed itself as an introduction to the learners' practical activity which they had been told to prepare for in the previous lesson. The discussion however seemed to give the learners a perspective that a site is always a quadrilateral, a square or rectangle in particular (see the extract below).

> **01: T3:** What is a site?
> **02: Puly:** Site *(in her Sesotho language)*
> **03: T3:** Site is "sets'a" in Sesotho. So each one of you, is going to have his or her site, right? And make sure that your site is a certain shape… What is the usual shape for sites in Lesotho? Just remember the site at your home what shape is it?
> **04: Learners:** Square!... Rectangle!
> **05: Learner 1:** Triangle! [O*ther learners stare at this learner and laugh at him*]
> **06: T3:** Square, rectangle right? So if you're saying you have a site as a square…the sides are?
> **07: Learner 1**: Equal
> **08: T3:** Are Equal, so if you have decided to make a square, your square must have all the sides equal right? Two of the sides are equal! …And the other two! Equal… There's something small that you have left, the two sides are. [*Learners are silent*] ...they are parallel.
> **14: Learners' responses:** "Aah!" "Ohoo!" "Oh?"

Much of this discussion was led by the teacher's questions, which prompted the learners to participate by providing answers as a way of activating their prior knowledge of a site as a real-life phenomenon and properties of the shapes, square and rectangle. This therefore formed part

of an active instructional approach intended to introduce learners to the practical activity of forming sites. Though the act of probing for activation of their prior knowledge was engaging them actively, the teacher involved rote explanations of the properties of a square and rectangle which were meant to guide them on the type of shape they would design as their sites.

The teacher's introduction of the lesson through the idea of a site (and its usual shapes in Lesotho) seemed as an intention to lead learners to making links between the real-life idea of a fence (or length of) around the site and the concept of Perimeter (and its scientific explanation and definition). However, since this was in the very beginning of the lesson, the link-making process had not yet taken shape, hence the link that seemed to be made was the one between the real-life concept of a site and the geometric polygons, square and rectangle, described through their properties. Therefore, the teacher led a process of link-making to support knowledge building: making links between scientific explanations and real-world phenomena. Throughout this discussion, both the teacher and learners took turns in the talk with the learners providing answers to the teacher's questions including individual suggestions. This therefore indicated the use of interactive/dialogic communicative approach.

The teacher's presentation at this introductory part of the lesson was purely focused on introducing the concept of Perimeter through the analogy of a fence around a 'site'. This had to go via a review of properties of rectangle as a 'usual' shape of a site in Lesotho. The teacher-learner talk over this therefore was more on what a square or rectangle is and its equal-parallel-sides property. Since the discourse thereof was driven mostly by the teacher's explanation and probing of the learners, it was mostly structured and impersonalised hence objectified and could therefore be considered formal mathematical discourse.

Teacher Nkoe then ordered the learners to each go outside of the classroom and spot some piece of land to erect their sites. They were given further instructions for the activity, which included putting up sticks as poles at the corners of their sites and using pieces of string as the fence around the site. These materials (in addition to rulers and pencils) were readily available for each learner since they were told in advance to bring them to class. The following extract shows the discussions as the teacher gives instructions and probes learners to ensure clarity of the instructions.

> **15: T3:** Two of the sides are equal! …And the other two! Equal… There's something small that you have left; two of the sides are equal and the other two are equal. The two sides are? The two sides are. [*Learners are silent*] they are parallel.

16: Learners: "Aah!" "Ohoo!" "Yes!" "Oh?"
17: T3: If you say your site is ... this size, it needs four poles. Now let… or… those who have a wire, right? You must be able to go round your site okay? [*T3 moves his finger around the Perimeter of the book on his desk as he demonstrates*]
18: Learners in a chorus: Yes, sir.
19: T3: When you start your site you first start with the poles at the corners…so that is what exactly you're going to do. And make sure that once you put your poles you also know how long each side is – and when we say how long what are we talking about?
20: A few learners (*mumbling*): Length.
21: T3: The length. And what are the units of length? What are the usual units of the length?
22: Learner (in the background): Sir I think centimetres.
23: T3: Centimetres, maybe meters. Fine, right? …So the length can be measured in cm, but after you have made your site from each your poles you're going to measure each side, right?
24: A few learners: Yes, sir.
25: T3: So… each one of you is going to choose her site as we go outside. And then you're going to make the shape of your site – some of you are going… say we want to make…, a square site, right?
26: Learner (in the background): Yes, sir.
27: T3: Alright, eh let's take our instruments and go out. [*Learners take instruments (rulers and strings) and go out*]

As demonstrated in this excerpt, teacher Nkoe probed learners to identify more properties of the rectangle, specifically properties related to the sides of the rectangle (that is, parallel sides). After their failure to respond correctly to the teacher's leading question (showing lack of memory on parallel-sides property), the teacher resorted to telling the learners that the sides were parallel. This he did as a way to remind them and provide further explanation as a summary to ensure they remembered that property. This gesture therefore indicated Nkoe's use of direct instructional approach. Further, part of the introductory section of the lesson involved the teacher's emphatic guiding rules before the learners could begin the practical task of designing their sites as an introductory experience leading to development of knowledge on Perimeter of a shape.

In terms of instructional and conceptual accuracy, Nkoe's utterance of the question '*What is the usual shape for sites in Lesotho?*' which was followed by 'square and rectangle' responses and the prolonged discussion on squares and rectangles, gave the learners the inaccurate impression that a site can only be in the shape of a square or rectangle. This was further observed when one learner mentioned triangle and the class giving a surprised laughter (line 05 in the extract). Consequent to this, as discussed in the extracts that follow herein, the learners got stuck in the use of the '2L+2W', which only applies to rectangles. Though the activity was to be an explorative way by which learners would drive towards knowledge development on

concept of Perimeter, the teacher's repeated and direct guide into the task made it a listen-and-follow-the-rule ritual which observably lacked aim.

On this part of the lesson, where the teacher's focus was to give and clarify instructions for the practical session, most of the talking was done by the teacher. The learners only took part through short responses, mostly '*yes sir*', hence the interaction involved an interactive/authoritative communicative approach.

After the prior knowledge activation session in the classroom, the teacher commanded the learners to take their tools and walk outside to execute the practical task. Upon reaching outside, each learner spotted their sites and started scraping the floor and plugging in their 'poles' in the ground [see **Figure 4**]. While each learner appeared to be fully engaged in the task, the teacher kept moving around between the learners to check on their progress.



Figure 4. Learners scrapping the floor and plugging 'poles' to mark their 'sites'

As his monitoring role during this task, the teacher visited each learner randomly to provide further guide on how the task could be correctly done. For instance, at some point teacher Nkoe approached one learner, Tebello, who was scrapping the floor to flatten it before placing the 'poles'. He then started telling Tebello what to do and how to do it as demonstrated below:

28: T3 (*to Tebello*): No! Leave the interior part, just put your… your poles. When you have done that, it's fine.

The teacher then went to Mosa to check on her progress. As a way of redirecting her activity, the teacher repeated the instructions to her and physically helped her to place the thread around the 'poles' in the ground and helped her to complete the task. However, Mosa's questions as she received the guidance were too direct, hence indicating some lack of understanding of the task or its purpose. She also showed that she only relied on the step-by-step demonstration she was receiving from the teacher (see the extract and figure below).

[*T3 walks between the learners and stops in front of Mosa*]
29: T3 (*to Mosa*): Yes, now you take your thread and wrap it around… it is long, isn't it… [*Mosa takes out her thread*] yes and then! … [*Mosa wraps her thread around poles of her site*] You're starting from here isn't it?
[*T3 points at one of the poles where one end of the thread should be placed*] You hold it like this, you hold it at that point.



Figure 5. *Teacher demonstrating to Mosa*

30: Mosa: Okay, that's all sir?
31: T3: Yeah that is all hold it at that point where it ends, you will go into the classroom holding it right there where it ends. [*Mosa pulls out the thread from her poles, holding it at a point shown*] Yes, when you have done that you're fine, you go…. You go inside and measure the length of that from there to where you start.
32: Mosa (*to T3*): Should I take the sticks?
33: T3: You can leave them here; you'll take them after.…during break. [*Mosa picks her thread and goes to class]*

The teacher's repetition of the instructions and physical (moving of instruments by hand) guide of the learners to perform the practical activity showed that he believed in direct instructional approach where learners are authoritatively guided to perform their activities. However, the learners were fully hands-on in the activity, hence an active instructional approach was used. The teacher's interventions – as the learners executed the task – involved explicit verbal and physical assistance to them. This included a step-by-step guide on how a learner should perform the activity to get it correct. This therefore did not allow the learners to explore several options of executing the same activity. They were also not probed to provide the reasons why they

performed the activity the way they were doing as a way of helping them to have deeper understanding of the activity. This thus indicated the routines of the teacher and learners as rituals purely aimed at completion of the task as instructed.

Since the teacher's focus was mostly on guiding the learner on how to hold and use the tools as part of the activity, most of the teaching was done by the teacher. Though the learner responded with a '*yes sir'* and posed some questions seeking further guidance, the communication lacked dialogue. The interaction between the teacher and the learner was an interactive/authoritative communicative approach.

The rest of the practical session proceeded in a similar manner, with the teacher randomly visiting individual learners as each tried to complete the practical task. Those who succeeded in the task moved back to the classroom to record the measurements (length of the thread). However, similar to Mosa, most learners had some problem completing the task on time. The teacher therefore spent time telling each learner, he visited, what to do to complete the task. At some point he realised that most of the remaining learners had a problem performing the assignment as instructed, hence he addressed the remaining learners. In his address, teacher Nkoe brought the learners to attention and narrated the instructions explicitly and then continued his individualised visits till the majority of learners had finished and went back to the classroom (see the extract below).

> **34: T3 (*to learners*):** Okay. Okay listen, listen, listen; you put… you put the string at one corner, right?!
> **35: Learners:** Yes, sir.
> **36: T3:** And then the string goes around, when you arrive at that corner hold the string at that point, right?
> **37: Palesa:** Yes, sir! [*She says this listening attentively to T3*]
> **38: T3 (*to learners*):** we understand each other, isn't it? While one end is at the corner, when you have gone around, hold the thread where it reaches the first pole and come into the classroom with it, as it is.
> **39: Learners:** Oh!?
> **40: T3:** Yes! Get inside holding it right there.

For this out-side-classroom practical task, the teacher's focus was to ensure that each learner completed the task (mark the four corners of site with poles, wrap the thread around the site and take the measurements, then move to the classroom). The activity therefore turned into a unidirectional command-action interaction between the teacher and learners, thus the teacher deployed direct instructional approach to ensure that each learner completed the task. Learners attentively listened to the teacher and eventually performed the activity without a clear purpose

of the task hence most of them had a difficulty completing it. This therefore indicated the teacher's routine as ritual and the instigated learners' routine as a ritual as well.

As shown in the above extract, only the teacher did the actual talking since he was re-narrating the instructions of the activity. Learners only participated by a '*yes sir*' response then went back to the hands-on activity before moving back to the classroom. This therefore indicated the teacher's use of non-interactive/authoritative communicative approach.

The second part of the learners' task was to be performed in the classroom where they took their threads which they had used as 'fence for their sites' and measured its length and recorded the measurements in their exercise books. As the learners recorded their measurements, they moved around from desk to desk and discussed amongst themselves and showed each other their recordings, hence the class appeared to be noisy and chaotic. A few learners remained outside to finish up with the wrapping of their sites with the thread. The teacher entered the classroom and started drawing (and labelling Length and Width) a rectangle on the board. He then called the class to attention and gave them some more instructions to complete the task. The instructions included the measuring of the length of the thread used outside and recording the length in their exercise books. In his elaboration of the instructions, Nkoe told the class that for their rectangular site, they had to record the measurements for length and width, and that '*the third measurement would be the Perimeter*' of such a rectangle. The latter statement came out as a surprise to the learners since it was the first time *Perimeter* was mentioned to the class.

Nkoe's main duty at that stage of the lesson was to visit each learner at their desks to check how they had measured and recorded the length of the thread. While on this duty, Nkoe had to tell some learners to go back outside to redo the 'site fencing' task and bring inside the thread held or marked at the point where the measuring would start. The following extract shows the teacher activities and communication with learners as he monitored their progress on the task:

> [*At one front desk a group of learners with threads and rulers are discussing and helping each other on completing the task*] [*After most learners have gotten to the classroom, T3 begins to draw on the board*]
> **41: T3 (*to* *class*)**: I give you three minutes to measure… and you record down the length of your string, right?
> **42: Learners in chorus**: Yes, sir.
> **43: T3 (***to class*): When you are done with the length of the string I come to you and check. Meanwhile as we're waiting for the others, those who have finished, I'll come and check. You record…if you have a rectangle, you record the length and the width, isn't it? You have to show me how much was your length and your width. And then the third reading will be the reading of your Perimeter. …So if you're

through raise up your hand, I'll come and check… [*T3 keeps moving around examining the learners' progress*]

44: T3: No you don't draw, okay? You don't draw, just eh record calculate your length, tell us what was your length and your width.

45: T3: Length of the string. Yeah the whole length of the string.

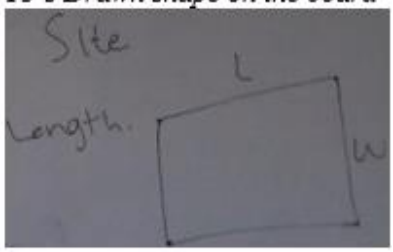
46: Seipati: Oh the whole length?

47: T3: Yes… you measured the length and the width isn't it? Of the shape?

48: Seipati: Yes, sir.

49: T3: So I just want to know the length of that string.

T3's Drawn shape on the board



As chaotic as the class was, the learners showed active engagement in the task of measuring the sizes of their threads. The teacher's actions of drawing the rectangle and labelling its sides, length and width, and elaborate instruction on the measuring of the length and width, gave the learners the impression that a site is a rectangular shape. They were never provided with a substantial reason or purpose of their measurements (only a repeated set of rigid instructions) until the next session when the teacher provided a lecture on the concept of Perimeter. In this part of the lesson therefore, the learners followed the instructions unconsciously and aimlessly just to satisfy the teacher. In that duty, they showed dedication to get the task accurately done by walking back outside to redo the task ('fencing' and marking the length of the fence around the site) when they were told it had not been properly done. This therefore indicated that the teacher and learners utilised ritual routines to execute the teacher's activity. His interaction with the learners involved a unidirectional talk as he directed learners to execute the given task correctly and accurately. The interaction therefore featured a non-interactive/authoritative communicative approach.

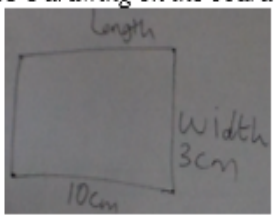
As a continuation of the lesson on Perimeter, after each learner had recorded their measurements, teacher Nkoe called the class to attention and ordered the learners to sit down and listen. He then led the presentation on the re-introduction of the term 'Perimeter' by its definition, while directing the learners to refer back to their measurements of their sites as examples. To further demonstrate the concept of Perimeter, Nkoe labelled the rectangle he had drawn earlier on the board with the sizes of its sides. The lesson then went on with the teacher mainly leading the proceedings. For this part of the lesson, Nkoe mostly led the discussion by explaining and relating the prior task to the concept of Perimeter. The teacher's actions included probing learners to seek their thinking on the naming of the concept of Perimeter after providing its definition in relation to the '*fence around the site*' analogy. For this particular

probe, the learners failed to provide the response as expected by the teacher, hence he provided the naming with some further elaborations.

The probe at this stage further took much of the time on the appropriate units for the length of the 'site' as it compared to the height of a human being. Though the discussion was aimed at showing learners that three centimetres or three meters were not appropriate for the height of a human being, the teacher used the units inaccurately when making an example with the action of 'walking around the side' and distance of three centimetres. The following extract shows the teacher's interaction with the learners as he introduced the concept of Perimeter:

[*Learners are seated quietly in the classroom listening to T3 as he teaches*]

T3's drawing on the board



50: T3: If your length was ... 10 cm, [*T3 labels one side of the rectangle on the board as "10cm"*] the length of one side of your site was 10cm and the other one was 3cm.
51: T3: And each one of you are looking at your readings, right?
52: Learners: Yes, sir.
53: T3: You see now if you have 10 here, [*points at "10cm" side*] plus three, [*points at "3cm" side*] how much is… was the other side?
54: Learners in a chorus: Ten!
55: T3: And then here? [*Pointing at the side opposite the "3cm"*]
56: Learners in a chorus: Three centimetres.
57: T3: Three centimetres – it is very important… to get the units right, right?
58: Learners in a chorus: Yes, sir.
59: T3: Because if you say ten metres you're talking about something else. if it's about you, you say you're 3cm tall you will be happy isn't it?
60: A few learners' responses: "Yes sir!", "No!"
61: T3: Why? Somebody who says you're 3cm tall it means... is saying you are a dwarf. [*Learners laugh*] If he says you're 3 metres tall; can you be 3 metres tall?

The teacher's drawing and labelling of the rectangle and guiding learners through its properties and units of size of its sides was an indication of his use of direct instructional approach. This is due to the fact that he mentioned the learners' measurements from a practical exercise just in passing and proceeded by explaining and authoritatively probing them to focus on his labelled rectangle as a way of leading to the concept of Perimeter. This is in addition to the mentioning of the word Perimeter without a clear connection of such word, the learners' practical activity and the drawn rectangle on the board. The teacher therefore failed to make any pedagogical link between the learners' practical activity and the concept of Perimeter, or between the idea of fence around the site and the concept of Perimeter or its definition. This therefore also indicated the teacher's ritual routine which was intended to introduce the Perimeter of a rectangle through the teacher's explanation. Since his focus was to tell the learners about the concept of Perimeter as it applies to a rectangle, most of the talking was done

by him in explaining and posing questions for learners to follow his explanation. The learners only participated by providing guided responses which indicated they were following the teacher's lead. Therefore, the interaction with the learners featured an interactive/authoritative communicative approach.

The next teacher-led question-answer discussion was on the attainment of the Perimeter of the rectangle. The teacher probed learners to come up with a computational procedure of a Perimeter by calling it by its definition. The teacher further posed a series of questions in relation to the definition of Perimeter and the idea of a site and its measurements which the learners had conducted outside the classroom. This therefore, allowed them to engage actively in the discussion since each learner had to work out and provide a response.

The teacher further tried to probe the learners to come up with the name of the total distance around their sites, which was meant to introduce the new term, Perimeter. Though this was an active move for learners' engagement, they failed to mention the term hence the teacher resorted to telling and relating the term to the idea of walking around the site, and adding all the sides of the rectangular site (see the extract below).

> **62: T3:** If you were to go round your site, you want to know how much distance have you covered? …if this is your site, the one in centimetres that you have drawn; if that is your site you want to know how much distance do you cover when you go around your site. How much distance do you think you have covered?
> **63: Ts'epo:** Twenty-six centimetres.
> **64: T3:** Centimetres! Because you first walk 10 centimetres, right?
> **65: Learners**: Yes, sir.
> **66: T3:** And then you walked three centimetres, and then you walk?
> **67: Learners**: Ten centimetres.
> **68: T3:** Ten centimetres and the last three centimetres. And ten centimetres is the length, right?
> **69: Learners:** Yes, sir.
> **70: T3:** So… now if you go around the shape, [*T3 moves his hand around the rectangle*] that total distance do you know what do we call it? [*Learners are silent. A few learners then answer "No sir"*] who has an idea of what we call it? That distance that you walk around your shape is called Perimeter. [*T3 writes "Perimeter" on the board*] And you see that, for those who did the exercise correctly, you see that when you add all the lengths,
> [*T3 points at the four sides of the rectangle*] it was the same as the length of the string, right?
> **71: Learners**: Yes, sir.
> **72: T3:** … in other words, the same distance I can draw one line, which is… how long is that line?
> **73: Learners:** Twenty-six centimetres.

The teacher's gesture of telling learners the definition and the term Perimeter added to his series of practices which showed direct instructional approach. This is due to the fact that the connection of the learners' recorded lengths of their sites from outside the classroom, with the new term Perimeter, was articulated by the teacher instead of allowing or probing learners to

attempt the connections themselves. However, they were kept active by the teacher posing a series of questions which included those demanding them to perform some calculations before responding. Though the learners were involved in a question-answer interaction, the posed questions did not demand their deeper thinking or understanding of the concept of Perimeter. They were never probed to provide any argumentative reasoning towards their responses, thus the teaching and learning routines at this stage of the lesson were rituals.

Though the teacher mostly used and emphasised the idea of 'walking' around the site, he tried to probe learners to make a connection between the idea of fence-around-site to the concept of Perimeter and its definition. In this probe, learners showed lack of capacity to execute such link-making process, hence the teacher provided the link-making explanation by himself. He did most of the talking while trying to lead them to produce such link. The communication therefore lacked dialogic interaction since the learners only provided short answers for the size of sides or arithmetic process thereof, without any opinions or arguments raised. Thus, the teacher led a link-making to support knowledge building: making links between scientific explanations (concept of Perimeter and its definition) and real-world phenomena (the distance walked around the site or length of fence around the site), through an interactive/authoritative communicative approach.

Teacher Nkoe also tried to lead and probe the learners for a computational procedure or any procedure for obtaining a Perimeter of the rectangle, and for them to use the measurements they had obtained from the practical session. However, some of the learners suggested a '2L + 2W' formula, which led to the teacher abandoning his pre-intended procedure of adding all sides and focusing on the suggested formula. That gesture also showed that the learners had some prior memory of the formula, hence it hindered them from following the teacher's intended procedure, and making conceptual connections between the definition and the computational procedure (adding all sides). The teacher thus led the discussion on the formula and made a concluding explanation that to obtain the Perimeter, that was the formula they had to use (see extract below).

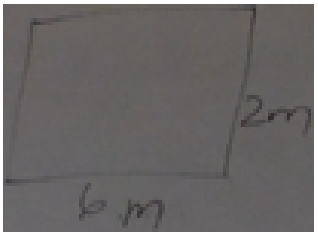
> **74: T3:** Twenty-six centimetres. So, if you have a rectangle, right? Is there a way of finding the Perimeter of a rectangle? Let's say we have 5cm and 15cm here. Is there a better way of finding the Perimeter of that?
> **75: Learner (in background):** Yes, sir.
> **76: T3:** Yes? How? What did you do?
> **77: Puly:** I said length times two.
> **78: T3:** Why length times two?

79: Puly: Because the lengths have got the same…
80: T3: Aha! The two parallel sides? Equal! So, you're saying your Perimeter of a rectangle is equal to two times the length?
81: Puly: Yes, sir.
82: T3: What else?
83: Learner H: It's two times length plus two times width.
84: T3: Yes! You added twice the length, then… twice the width…So given any rectangle, you can be able to find the Perimeter. That is how you find the Perimeter; twice the length, twice the width.

The teacher's gesture of giving learners an opportunity to suggest a computational procedure was a way to engage them actively in the development of their knowledge. However, the option of sticking with the formula which did not connect or use any results from the practical session showed that the teacher was not interested in conceptual understanding of the learners but the use of the already-known formula. This lack of interest in deeper understanding and rote use of the formula also indicated a ritualised teaching approach. This is also indicated by the teacher's failure to relate the formula to the definition discussed or the fence-around-the-site idea. He did most of the talking as he posed questions, demanding learners' suggestion of a computational procedure, and providing the concluding explanation of such formula. Learners therefore participated by accordingly responding by suggesting the formula and answers to the arithmetic process uttered by the teacher. This therefore indicated that the teacher-learner interaction featured an interactive/authoritative communicative approach.

The next classroom action focused on the use of the formula just discussed. The teacher provided learners a chance to use the formula to work on the Perimeter of the drawn rectangle on the board, hence he moved around to check his learners' progress and accuracy in the use of the formula. This included giving an exercise from the learners' textbook and copying the questions on the board. The exercise was meant for learners' practice and perfection in substituting the length and width into the formula and accurately executing the multiplication and addition operations. The learners were ordered to do the exercise in groups. Due to the ease through which they worked on the exercise, they spent most of the time on off-concept discussions while the teacher moved between the groups to monitor progress and accuracy of using the formula.

85: T3: … let me see, let me see, … [*T3 goes to the board and draws the rectangle*] Find the Perimeter.
[The rectangle drawn by T3 on the board]



[*Learners open their exercise books and begin to write. T3 keeps moving in between the learners' seats as they silently copy down and work on the questions*]

The teacher's action of giving learners an opportunity to work on the exercise as a way of practising the use of the discussed formula was an act of actively engaging them in the uptake of the use of the formula. However, this routine was not guaranteed to help learners attain the conceptual knowledge of the concept of Perimeter but to master the rote use of the new formula.

Though the lesson began with a practical activity, which mostly involved actions of active instructional approach, the classroom part of the lesson involved much of teacher's actions of direct instructional approach. As shown in above extracts, these included actions such as:

- giving an example and explanation on the new concept to be learned – the concept of Perimeter – by drawing and labelling to help learners relate their diagrams to the given example;
- explaining and telling to make learners identify the appropriate units for height of a person as an example leading to them identifying the right units for length of a 'site';
- probing to seek learners' suggestions of the total distance around the shape's name and telling the answer (Perimeter) when learners did not provide the answer (introduction of the concept by its definition and name);
- connecting the concept name Perimeter, its definition and computational procedure (addition of all sides) by telling and explaining to learners and explaining to them how these were related to the task they had just done (disallowing learners to make connections themselves);
- leading learners with simple questions to enable them to remember the formula and state it completely;
- making a concluding summary and stating the formula explicitly to affirm it correct and as the standard procedure for all rectangles; and
- giving learners exercise similar to the prior example as a way to make them practice and perfect the use of the formula.

In all these actions, learners had very little involvement, and when they responded to teacher's leading questions, they provided simple responses, hence they were largely inactive.

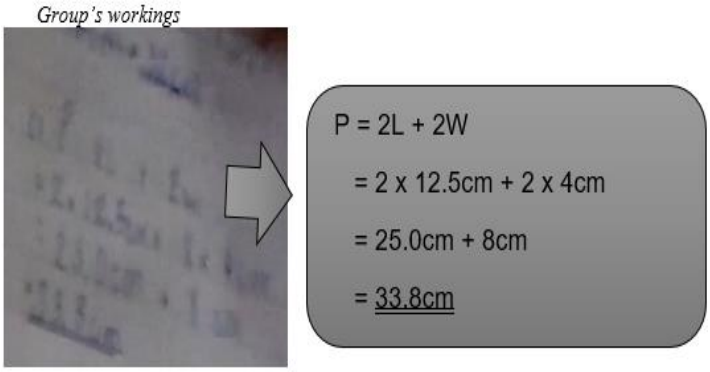
A few classroom actions at this part of the lesson had a few elements of active engagement each at their measurable intensity. These actions included: elaborating and probing learners to relate their measured lengths around their sites to the new concept of Perimeter; and probing to lead learners to narrate the computational procedure they could use in calculating the Perimeter of a rectangle as it applied to the given example.

Besides dominantly using a direct instructional approach, most of the teacher's routines proved to be rituals. These routines were signified by actions such as: direct telling that the length of the thread around the 'site' is the Perimeter, without enough substantiation and indication of the critical attributes of the concept Perimeter as it applies to the given 'site' analogy; probing learners to narrate the formula or procedure for calculation of Perimeter without a probe for deeper understanding of the formula (a pure retrieval of procedure from memory); giving and working on the example to demonstrate how the formula works; giving the exercise (similar to a worked example) for learners to practise the rote use of a formula for the Perimeter of a rectangle, and for learners follow suit.

As his ritual routine to ensure that learners master the rote use of the discussed formula and units of length, Nkoe proceeded by moving from group to group to check learners' work in their exercise books. He then marked correct or probed to remind the learners how to carry out the arithmetic processes in the formula (multiplication by 2 and addition of the products) and write the correct units. For instance, Nkoe attended to one group who were calculating the Perimeter of a rectangle with L = 12.5 cm, W = 4 cm. The group had correctly used the formula by substituting into it the given dimensions. However, they committed a computational error when they added the two products. The teacher therefore probed and guided them to realise their error, hence they corrected by redoing the steps in the arithmetic procedure (see the extract below).

86: T3 (*to the group*): Okay two times twelve-point-five is twenty-five, twenty-five plus eight. No! How did you get this three-point-eight?
87: Mollo: Sir the eight comes before the decimal point or?
88: T3: Show, I just want to see what you did.
89: Mollo: Okay, Sir I wasn't sure if this eight…
90: T3: But let's look at the answer that you have. Okay so… I have a problem with the answer… now if you say 33.8 I get what you did here. Remember, we have twenty-five-point-zero, [*writes "25.0"]* what is the place value of five?
100: Mollo: It's the units' sir.
101: T3: it's the units. Eight, what is the place value of eight?
102: Mollo: Units sir.
103: T3: So … Eight is unit therefore it should be under 5

Group's workings



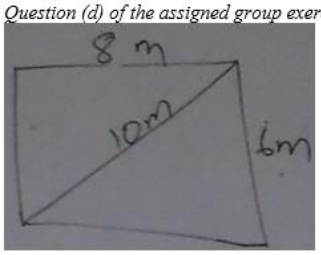
In his monitoring duty, Nkoe actively engaged his learners by probing them to narrate the arithmetic processes they had used and how they had applied the formula. However, to correct their arithmetic errors, the teacher directly rejected their procedures and answers and explained to the group how the work was to be done and what answers they were to find. The learners were also not probed to reason out why they believed their work was correct in order to study their level of understanding of the concept. Therefore, the teacher's practice was ritualised and led the learners to perform rituals as they worked and corrected their workings. The teacher did much of the talking while posing guiding questions and explaining to show the learners their errors in performing the arithmetic process. The learners – on the other hand – were involved in the conversation by explaining how they had carried out their workings and responding to the teacher's guiding questions. However, their responses did not involve any argumentative reasoning or substantiation of their arithmetic processes. Thus, the teacher-learner interaction in this part of the lesson involved interactive/authoritative communicative approach.

Soon after going around the classroom to check on the progress and accuracy of computations in each group, Nkoe called the class to attention and started probing learners to discuss the correct answer to the exercise they had just worked on. In this discussion, the teacher repeatedly reminded them about the definition and the computational procedure or formula for Perimeter of a rectangle. He put more emphasis, in his explanations, on using the outside dimensions of the shape, not the inside diagonals. For this exercise, the teacher wrote and explicitly explained the required steps for computation of the Perimeter of a rectangle to the final answer. The activity was aimed at showing the learners how accurately the exercise should have been done.

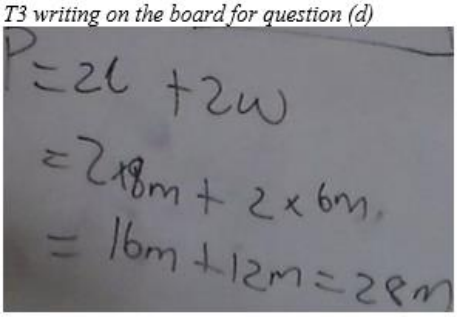
The following extract shows the teacher's communication and actions as he explains how the exercise should have been executed.

104: T3 (*to class*): can I get your attention please? So what should be the Perimeter of number (d)? …We said Perimeter is equal to two times length!...
105: Learners in a chorus: Plus, two times width
106: T3: Plus, two times width. Did we say anything else? [*Writes:*
"2L + 2W"]
107: Learners in a chorus: No sir.
108: T3: So what should be the Perimeter of (d)?
109: Learner 2: 2 times 8m plus 2 times 6m.
110: T3: 2 times 8m plus 2 times 6m, which is equal to?
111: Learners in a chorus: 28m.
112: T3: 28m, and what about the 10? Is the 10 around the shape?
113: Learners in a chorus: No sir!
114: T3: No! Everything inside has nothing to do with the Perimeter, do we understand?
115: Learners in a chorus: Yes, sir.

Question (d) of the assigned group exercise



T3 writing on the board for question (d)

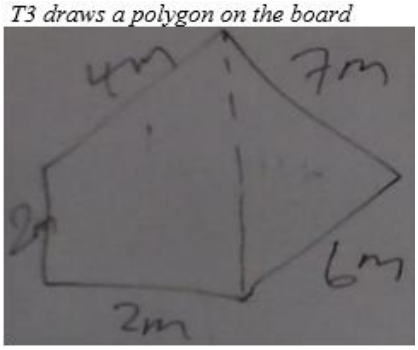


The process of explaining to the class how correctly the exercise should have been done and working out the exercise procedurally to show the final answer (while providing detailed explanations on which sides of the shape to use), indicated the teacher's use of authoritative direct instructional approach. This also showed the ritual nature of Nkoe's teaching since no substantiation and no new information was brought into the solution procedure; just a repetition of rote use of the previously given formula. As shown in the above extract, the teacher authoritatively led the discussion on the activity through leading questions and explanations. The conversation therefore lacked dialogic interchange between the teacher and learners since they were not given the opportunity to reason argumentatively for the work they executed and the way they did. This interaction therefore featured an interactive/authoritative communicative approach.

The teacher proceeded by drawing a pentagon on the board, as the next example, and probing learners on how its Perimeter could be calculated. However, the discussion never became

explicit on the computational procedure for the Perimeter of the drawn irregular polygon. Instead, the teacher drew a regular polygon and started probing and discussing its properties. The discussion proved to be an introductory preparation for the problem-set that was yet to be given to the learners. This supposition stems from the fact that the next action after discussion on properties of regular polygon, was distribution of problem-set sheets to the learners to work on. Following the brief discussion and distribution of the sheets, they began discussing amongst themselves as they read and worked on the problems in the worksheet. The teacher then proceeded with his routine movement around the classroom to monitor the learners' progress on the problem-set (see the extract below).

T3 draws a polygon on the board



116: T3: So if I have two, six, seven, four, two, [*T3 labels sides of the shape*] And then somebody decides to… say okay this is my site, I decide to have some fence here so that I can fence chicken, right? Does this mean my site has increased?

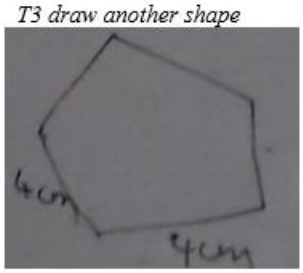
117: Learners in a chorus: No sir.

118: T3: Perimeter is everything outside okay? But if we say it's a regular polygon we mean all the sides are…equal! If I have 4cm here, how much do I have here? [*Points at the second side of the shape*]

119: Learners in a chorus: Four centimetres.

120: T3: All of them are...4cm. So… all you need is that information… for that question (*in the problem-set sheet*). And if you manage to get the Perimeter of that, I can assure you there's something that you're going to get *(a reward*). So I'm gonna give you an exercise [*starts distributing problem-set worksheets to groups*]

T3 draw another shape



The teacher's introduction of new shapes (polygons of more than four sides) and their properties was a way to hint or prepare learners for the problem-set they were yet to work on. This therefore indicated his use of direct instructional approach signified by a rote sequence of events: introduction and explicit explanation with demonstration, then learners' exercise for practice. This also indicated the teacher's ritualised teaching since the aim of the discussion was purely to tell learners the properties of polygons similar to those in the problem-set as a rote way to prepare them. Thus, no conceptual understanding was in focus for the learners at that moment. The teacher presented all the critical attributes of the polygons under discussion, with the learners providing short answers as led by his questions. Therefore, the interaction followed the interactive/authoritative communicative approach. The teacher also tried to make

a link between the idea of ‘fence around the site’ and the concept of Perimeter. However, this was never completed since the teacher rushed to discussing the properties of polygons.

In this episode, generally, the teacher’s routines were mostly rituals. On the outside-of-classroom practical session, during the teacher’s visits to their work-stations, the learners were never probed for understanding of the task or the targeted concept, Perimeter. Instead, the teacher repeated instructions for the task and physically helped them to take the measurements. Therefore, it could be argued that learners never understood the purpose or the processes of the task and were just following the teacher’s instructions and performing the task unconsciously, hence the routines were mostly rituals. As it unfolded throughout the episode, the teacher’s option of sticking with the formula which did not connect or use any results from the practical session showed that he was not interested in the learners’ conceptual understanding but the use of the already-known formula. This therefore formed the teacher’s ritualised teaching within his direct instructional approach.

The teacher’s action of giving learners an opportunity to work on the exercise as a way of practising the use of the discussed formula was an act of actively engaging them in the uptake of the use of the formula. However, this routine was not guaranteed to help the learners attain the conceptual knowledge of the concept of Perimeter but to master the rote use of the new formula, hence it showed the ritual nature of the teaching process. In his monitoring duty, Nkoe actively engaged his learners by probing them to narrate the arithmetic processes they had used and how they had applied the formula. However, to correct their arithmetic errors and erratic substitution of the dimensions of the shapes into the formula, the teacher directly rejected their procedures and answers and explained to each group/individuals how the work was to be done and what answers they were to find. The learners were also not probed to reason out why they believed their work was correct in order to study their level of understanding of the concept. This therefore showed his direct instructional approach which involved ritual routines. Also, the teacher’s introduction of new shapes (polygons of more than four sides) and their properties was a way to hint or prepare learners for the problem-set they were yet to work on further indicated his use of direct instructional approach guided by a ritual sequence of events: practice/introduction explicitly before exercise.

In this episode, the teacher executed two link-making explanations in trying to connect the learners’ practical session and the classroom-taught concept of Perimeter. These links were:

link-making to support knowledge building - making links between scientific explanations (concept of Perimeter, its scientific explanation and definition) and real-world phenomena (idea of length of a fence around the site); and link-making to support knowledge building - making links between scientific explanations (concept of Perimeter and its definition) and real-world phenomena (the distance walked around the site or length of fence around the site). In making these links and in other parts of the lesson, the teacher led interactions which involved three forms of communicative approach at different frequencies: interactive/dialogic communicative approach in one incident; non-interactive/authoritative communicative approach in two incidents; and interactive/authoritative communicative approach in eight incidents.

8.1.2 (Episode 2, Lesson 2) Nkoe's teaching approaches, discourses, routines and classroom interactions while teaching the concept of Area

In Nkoe's classroom, the concept of Area was taught on the bases of two non-related yet coherent attributes of the concept. These are: its definition as it relates to Perimeter (previously taught and computational procedure practised), and computational formulae (relation between rectangle and triangle).

To introduce the concept of Area, teacher Nkoe made a brief review on the problem solution learners found from working on the problem-set in the previous lesson. The review proceeded through telling, explanation and simple probe to remind learners what Perimeter was and how it is different from Area. He did this by referring to the problem scenario from the problem-set, explaining that the fence (which represented Perimeter) enclosed the space occupied by other real objects in the yard. He then explained that the space enclosed is the Area of that shape. More emphasis was put on the definition of Area as the space bounded by the Perimeter, space occupied or used.

In terms of conceptual accuracy, though the definition was repeatedly elaborated and analogy used to distinguish it from Perimeter, one critical attribute, 'flat surface', was not made explicit. It could be argued that this had left the definition of Area incomplete and easy to confuse with the definition of volume as learners proceed further with Mensuration. Throughout this introduction session to the concept of Area, learners were mostly involved by providing simple answers to the teacher's leading questions. These included an admissive response '*yes sir'*

which always followed prolonged explanations by the teacher. The following two extracts show teacher-learner interaction during introduction of concept of Area.

> **121: T3:** Now, after you've fenced you want to know how much space do you have inside, okay?
> **122: Learners in a chorus:** Yes, sir.
> **123: T3:** And that space that is inside here, [*T3 points at the region inside the rectangles drawn on the board*] this space inside the site is called Area, right? It is that space that is occupied. You've fenced it, now you want to know how much space have I used, alright?
> **124: Learners in a chorus:** Yes, sir.
> **125: T3:** …you want to find how much Area is enclosed in that Perimeter…right?
> **126: Learners in a chorus:** Yes, sir.

In this introductory part of the lesson, teacher Nkoe led a presentation which mostly involved explanations related to the new concept of Area and its relation to previously discussed Perimeter. This therefore indicated the teacher's use of teacher-dominated direct instructional approach. Due to direct instructional nature of the presentation, most of the teacher's presentation involved colloquial discourse which was focused at introducing the new concept of Area through its definition.

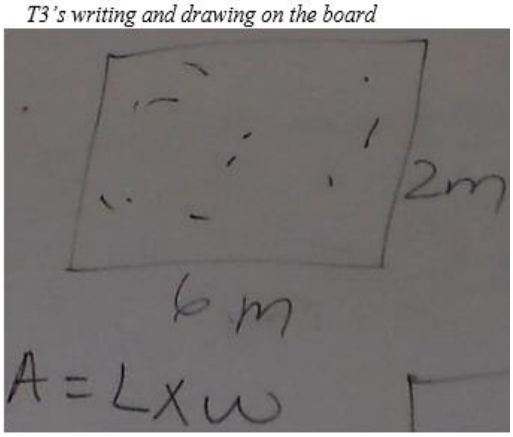
Though learners' voices were heard during the teacher's presentation, they only contributed by giving a '*yes sir*' response to his confirmatory question, '*right?*'. Therefore, this interaction featured an interactive/authoritative communicative approach. The teacher's presentation involved a connection between the space inside the fence and the concept of Area. It also involved the connection between the two concepts, Perimeter and Area. Therefore, the teacher executed two links both related to the concept of Area. These are: link-making to support knowledge building: making links between scientific explanations (definition of concept of Area) and real-world phenomena (the space enclosed by the fence of a site); and link-making to support knowledge building: making links between scientific concepts (Concept of Area as space enclosed by Perimeter, and concept of Perimeter as a boundary of Area).

Soon after providing the definition of the concept of Area, the teacher provided the computational formula for this concept of Area, but specifically for the rectangle. This was done explicitly by telling and writing the formula ($A=L\times W$) on the board. The teacher then provided an example with the rectangle which was used for calculation of Perimeter, probing learners to remind them the Perimeter they obtained previously. They remembered the value they obtained and responded accordingly. Teacher Nkoe therefore substituted (verbally) the length and the width into the formula and probed learners to ensure they could identify the length and width of the rectangle in the example, and used the formula to find the correct value

for the Area. The discussion also included identifying and using appropriate units for Area. The following extract shows the `observed activities in this section:

127: T3: So when finding the Area of a rectangle…, the Area of a rectangle is simply length times width. [*T3 writes the formula: "A = L x W" below the 6m by 2m rectangle*] In this case … how much Area do you ave in that rectangle? …you have a rectangle of 6 by 2 right?
128: Learners: Yes, sir.
129: T3: How much Area do you… is enclosed in that Perimeter? …we said Perimeter was how much? The Perimeter of this shape was how much?
130: Learners: Sixteen meters.
131: T3: That sixteen meters encloses how much Area? Area of a rectangle equals to six meters the length, times the width which is?
132: Learners: Two meters
133: T3: Two meters… Six times two?
134: Learners in a chorus: Twelve!

T3's writing and drawing on the board



The teacher's act of directly providing learners with the formula for the Area of a rectangle indicated his preference for direct instructional approach which is mostly driven by telling, explicit explanations and rote use of formulae. This also indicated the ritual nature of the classroom routines since there were no further elaborations or probing regarding the derivation of such formula and its relationship with the definition. The teacher's talk involved mathematical formula and terminology related to Mensuration concepts, Perimeter and Area, thus making the discourse mathematical.

The teacher's leading questions (*'How much Area… is enclosed in that Perimeter?'*) in this discussion created the connection between the concept of Area and concept of Perimeter, emphasising on his prior utterance that Area is the space enclosed by Perimeter. Therefore, the teacher executed a process of link-making to support knowledge building: making links between scientific concepts. His talk involved telling and leading questions for learners. The questions demanded them to remember the value of Perimeter previously calculated and relate it to the Area of the same rectangle on the board. The learners thus responded with a '*yes sir*' and provided the value of Perimeter they had obtained earlier, without any new ideas or argumentative discussion on the teacher's questions. Therefore, the interaction between the teacher and learners involved an interactive/authoritative communicative approach.

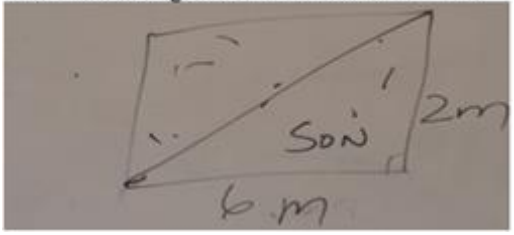
The teaching in this part of the lesson was focused mostly on learners' acquisition of the appropriate formula for calculating the Area of a rectangle, and developing their skill to use it accurately. Though the teacher kept probing with some leading questions, and a frequent *'right?*' confirmatory, the learners' engagement was mostly a passive participation, hence the teacher was mostly using direct instructional approach. This reflected in actions such as: making a review on the previously taught concept, Perimeter; providing the definition of concept of Area; directly providing the formula for Area of rectangle; providing an example while leading learners through the computational process; and probing to lead learners to master the use of units in the calculation of Area.

In this part of the lesson, the teaching routines, as reflected in the extracts presented, were mostly rituals. Though in some instances questions were posed towards learners, most of those questions were finally answered by the teacher hence providing the expected narrative (the definition of Area; computational procedure; appropriate units for Area). The provision of the formula and working through the example was another ritual of finding and showing the correct computational procedure, which was not to be missed by the learners when tackling similar problems. The teacher provided an explanation and questioning that led to a link-making process through an interactive/authoritative communicative approach.

With the aim of introducing the computational procedure or formula for the Area of a triangle, teacher Nkoe used the analogy of the 'site' being shared in halves by the parent to give one share to the 'son'. While narrating his scenario, he drew a diagonal line to the 6m-by-2m rectangle drawn on the board. He then posed a question requiring the learners to find the amount of Area given to the son, which the learners got correct. However, getting the correct answer was easier for the learners since it depended on the teacher's stating of a half, hence they simply took half of the Area of the rectangle which had already been calculated previously. The extract below shows teacher-learner interaction as he introduced Area of triangle.

135: T3: If this is your site and then you say, okay I'm going to share this part for… my son. [*T3 divides the rectangle into halves with a diagonal, Labels one half "SON"*]

T3 divides rectangle into halves and labels "SON"



136: T3: How much Area will the son have?
137: Senate (*softly*): Six meter squared.
138: T3: Six meter squared?
139: Few Learners: No…!
140: T3: No? When you say 'No' you must have an alternative, okay? Who says six meter squared? How did you find the six meter squared?

141: Senate: Sir half of the twelve is six so…
142: T3: The half of the twelve is six, so?
143: Senate: So I got six meter squared sir.
144: T3: Why?
145: Senate: Because six is the half of twelve.
146: T3: … why the half of twelve? So why do you choose half? Why do you half twelve?
147: Senate: Sir because you gave the SON half of the land.

As presented in the above extract, the teacher introduced the idea of a half by cutting the rectangle into halves and probing learners to acquire the Area of one half. This gesture seemed like a ritual aimed at allowing them to calculate the Area of triangle from the 'already-known' Area of the same rectangle. Even so, the teacher made the process to be somehow explorative by seeking alternative answers from those who said the answer was incorrect. He further posed questions seeking the learners to narrate the procedure he had followed to get the correct answer, and to provide the reason for doing it that way. The explorative nature of this routine was further made explicit by the learner's response (*Sir because you gave the SON half of the land*) which showed plenty of logic in the procedures used to obtain such a response. The teacher guided the learners with explorative questions to make them think critically and make connections between the Area of rectangle and Area of triangle. This therefore indicated the teacher's use of active instructional approach.

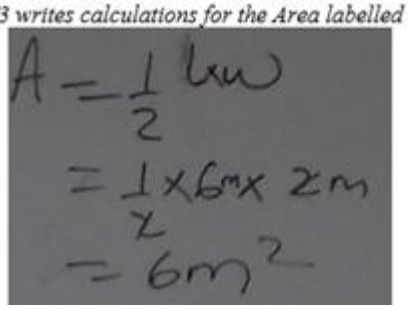
In the above extract, the teacher gradually introduced the idea of half of the rectangle as a triangle by using a site and sharing it for a 'son' as an analogy to make the learners understand quickly. This was therefore the teacher's link-making to support knowledge building: analogical link-making. Besides responding to the teacher's questions, which demanded their narration of followed procedure, the learners accordingly and logically responded to a 'why' question providing the reason related to the given scenario. This therefore indicated that the interaction between the teacher and the learners featured an interactive/dialogic communicative approach.

In continuation of the discussion on the Area of triangle, Teacher Nkoe approved the explanation by one of the learners (Senate) following his repeat-and-expand routine to elaborate further how the Area of a triangle is obtained from the Area of a rectangle. He finally provided a concluding statement (a narrative) to the procedure. In his statement, Nkoe insisted that whenever there is a mention of Area of triangle, learners should remember that it was cut from a rectangle hence it is '*half-length times width*'. The statement was soon followed by the writing of the formula as uttered and the calculations made with the dimensions of the cut-in-

half rectangle on the board, hence showing how accurately the answer could be obtained by the formula. The following extract shows the observed classroom activities and conversations at this part of the lesson:

148: T3: Yes! …You see that if you do that, then that is half of the land. You have six by two, right?
149: Learners in a chorus: Yes, sir.
150: T3: Six by two… So the two are equal right?
151: Learners in a chorus: Yes, sir.
152: T3: So meaning this is half. [*Points at the segment "SON"*] So the Area of a triangle… this shape is what?
153: Learners in a chorus: Yes, sir.
154: T3: So whenever we talk about the Area of a triangle remember it started as a whole rectangle. So the Area of triangle is half length times width. So, in this case we have half times six times two, right?
155: Learners in a chorus: Yes, sir.
156: T3: So which is equals to six-meter square.

T3 writes calculations for the Area labelled "SON"



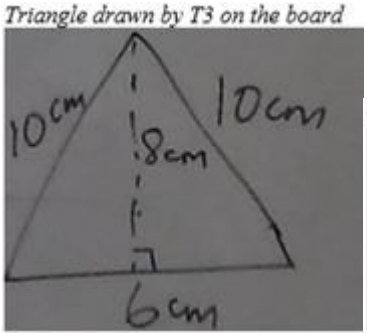
As shown in the above extract, the teacher wrapped up the discussion through an explicit explanation relating the Area of a triangle and the Area of a rectangle and providing a formula which results from such relationship. He further used the formula as demonstration of how it can be used for any triangle. This indicates that he resorted to the use of teacher-dominated direct instructional approach aimed at introducing and demonstrating the use of the new formula for Area of triangle. This also indicated his preference for ritual teaching routines which comprises signified explicit explanations of procedures, telling the formula to use, and rote demonstration on the use of the formula. The discourse therefore was more formal, including the endorsement of a narrative (*'the Area of triangle is half length times width'*).

The teacher in this part of the presentation took the central position by solely providing explanations and demonstration of the use of formula, while the learners only participated by responding with a '*yes sir*' to his confirmatory, '*right? isn't it?*'. This shows that the learners were somehow participating in the conversation, yet were not given the opportunity to raise some views or reasoning. Therefore, the teacher led a presentation driven by interactive/authoritative communicative approach.

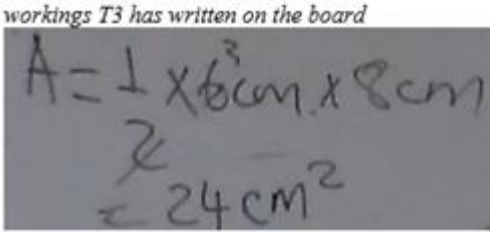
On his realisation that the generalisation endorsed in the above extract could only be clearly relatable to the rectangle for a right-angled triangle, Nkoe provided another example of an isosceles triangle and started explaining how the 'length' and 'width' could be identified in order to be substituted into the given formula. To make this explicit, he emphatically told the

learners to look for any two lines in the triangle which meet at an angle of 90 degrees, and those would represent the 'length and width' for that triangle. However, the teacher's explanations at this stage could be confusing to the learners since they were told not to 'worry about the rectangle' anymore, yet the initial discussion had emphasised that for any triangle, Area is always half that of the rectangle. Likewise, in this example and after explicit explanation, the learners were probed to identify the 'length and width' for that triangle hence led through computation of the Area using the formula as explained (see the extract below).

157: T3: You can be given a triangle and then you're asked to find its Area. Remember our formula has length and width, isn't it?
158: Learners in a chorus: Yes, sir.
Triangle drawn by T3 on the board



workings T3 has written on the board



159: T3: When you look at this where's the length, where's the width? …Once you're given a triangle, you look at the 90 degrees' angle, right? ...don't worry about the rectangle, you look at the right angle...Which two lines make 90 degrees in that triangle?
160: Tebang: Eight centimetre and six centimetre.
161: T3: Eight centimetres and six centimetres…so the Area of our triangle is… eight times three?
162: Learners in a chorus: Twenty – four…Centimetre squared.
163: T3: So you see when you say half-length times width, okay? You're simply saying half times the two lines that… make up 90 degrees. So when you're saying length and width remember the angle 90 degrees is playing a part, okay?
164: Learners in a chorus: Yes, sir.

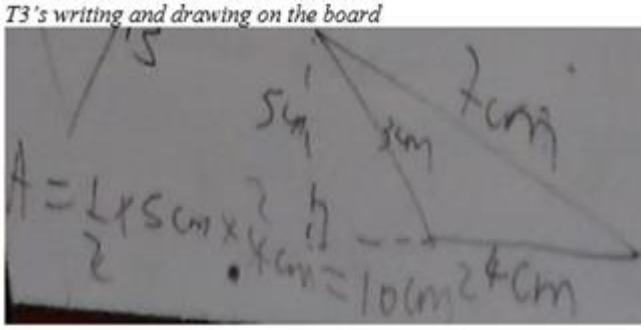
The teacher's unidirectional and emphatic explanation of how to identify the 'Length and Width' of the triangle and how to substitute them into the formula while working on the example, all indicated the teacher's use of direct instructional approach. The teaching routine displayed in this discussion were rituals since the focus on the rote use of the formula as it applies to an isosceles triangle. The learners were not given the opportunity to raise their opinions since he provided all the explanations for the critical points in relation to the new type of triangle and the formula to be used. Therefore, the teacher used the interactive/authoritative communicative approach.

In this section, though this was the teacher's attempt to show learners how the formula for the Area of triangle derived from that of Area of rectangle, it became the teacher's ritual to make learners memorise the formula as half that of a rectangle. A further demonstration of how the

formula works was provided with an example of a triangle which had its height outside the triangle. In the same manner, the teacher emphatically explained, probed and showed learners which dimensions of the triangle were 'Length and Width', hence leading them through the computational process to obtain the final answer. Most interestingly, the teacher made the learners aware that the usual formula uses 'base and height' instead of 'length and width'. However, on this latter issue, the teacher emphatically told the learners that his teaching had nothing to do with 'base and height' and he did not 'want to hear them ask him about those'. Due to the unidirectional nature of the teacher's presentation at this stage, the learners were kept passive while at times responding shortly with a 'yes sir' response to his confirmatory questions. The extract below shows the teacher's interaction with the learners.

165: T3: If our triangle is that one, [*T3 points at triangle*] We have to find its Area. Do we have the base? ... isn't it we have the length and the width?

T3's writing and drawing on the board



166: Learners in a chorus: Yes, sir.
167: T3: What is the length?
168: Learners in a chorus: 4 cm
169: T3: The width?
170: Learners in a chorus: 5 cm
171: T3: Okay…You see even if this triangle is there, sometimes we extend so that we can find that 90 degrees. So the Area of the triangle here is going to be half times 5 cm times 4 cm; which is 10 cm-squared, isn't it? Two into four it goes two times, five times two is ten, …I know that you'll often hear…Area equals to half base times height. I'm not saying that, okay? And you are listening. Don't ask me what is base and height, okay?
172: Learners in a chorus: Yes, sir.
173: T3: In the Area of a triangle all you need to know is that to find the Area you have to have 90 degrees; the two lines that make up 90 degrees. Half times the two lines that will make up 90 degrees.

The teacher's provision of a further example, with a triangle of different orientation and dimensions, was one more indication of his direct instructional approach. These actions were meant to allow learners to memorise and provide all the ways in which they can apply the formula in their calculation of Area. The learners, therefore, were gradually enculturated into the ritual routine. The teacher's emphatic telling on the strict use of 'length and width' instead of 'base and height' was a way to influence learners to stick to the use of only what they were told by him hence a further indication of his ritualized teaching. The teacher didactically presented the process of identifying '*length and width*' of the new triangle; substituting them into the formula; leading with a probe through the arithmetic process; and emphatically directing learners which terminology to use. All these he executed by using partially interactive communication since the learners were only heard when they said 'yes sir' or uttered a number

which was to represent length or width of that triangle. He therefore interacted with the learners through the use of (partially)-interactive/authoritative communicative approach.

In the sub-sections that make up this episode, most of the teaching routines were regarded as rituals and only one incident was marked as an exploration. The teacher posed questions requiring learners to find the amount of Area given to 'son', which they got correct. However, getting the correct answer was easier for the learners since it depended on the teacher's utterance of a half, hence the learners simply took half of the Area of the rectangle which had already been calculated previously. This gesture seemed a ritual tailored to allow learners to calculate the Area of a triangle from 'already-known' Area of rectangle. Even so, the teacher made the process to be somehow explorative by seeking alternative answers from learners who said the answer was incorrect. He further posed questions seeking the learners' narration of the procedure followed to get the correct answer, and to provide the reason for doing so.

Further, the teacher provided a series of unidirectional explanations in an attempt to show the learners how the formula for the Area of a triangle derived from that of Area of a rectangle. However, this gesture became the teacher's ritual to make learners memorise the formula as half that of a rectangle and make learners to strictly memorise the new formula and master its rote use. In addition to providing an extra example and further explanations on identifying the 'Length and Width' of the triangle, the teacher emphatically told the learners to strictly use 'length and width' instead of the usually-used 'base and height' whenever they were required to calculate the Area of triangle. This was a way to force learners to stick to the use of only the formula/properties they were told by the teacher, hence a further indication of his ritualised teaching.

Throughout this section, the teacher mostly used more structured discourses due to the authoritative and direct instructional nature of the teaching. In addition, though in most instances the teacher used personalising key words such as 'we have, our, you have, etc.', those statements only formed colloquial discourses which happened to be used in the midst of utterances of endorsed narratives about the computational procedures/formulae. The discourses therefore could be concluded to be impersonalised and structured, hence objectified (see the extract below).

> **174: T3:** Okay…You see even if this triangle is there, sometimes we extend so that we can find that 90 degrees. So the Area of the triangle here is going to be half times 5 cm times 4 cm, which is 10 cm,

> isn't it? Two into four it goes two times, five times two is ten. … So you see when you say half-length times width, okay? You're simply saying half times the two lines that make up 90 degrees. So when you're saying length and width remember the angle 90 degrees is playing a part, okay?

In this episode, teacher Nkoe's teaching was executed through the dominant use of direct instructional approach. This is with an exception of one incident where the teacher guided learners with explorative questions to make them think critically and make connections between the Area of a rectangle and the Area of a triangle, hence making his teaching approach active.

Throughout Episode 2, teacher Nkoe executed four link-making processes as a way of making his explanations explicit to learners. These links were: link-making to support knowledge building: making links between scientific explanations (definition of concept of Area) and real-world phenomena (the space enclosed by the fence of a site); link-making to support knowledge building: making links between scientific concepts (Concept of Area as space enclosed by Perimeter, and concept of Perimeter as a boundary of Area); link-making to support knowledge building: making links between scientific concepts (Area and Perimeter of a rectangle); and teacher's link-making to support knowledge building: analogical link-making (dividing rectangular land into halves by diagonal, share a half for a Son).

Due to Nkoe's direct instructional approach, most of these links were made by the teacher through explanations. He executed these link-making processes and other parts of the lesson through a communicative approach in several incidents: interactive/authoritative communicative approach in five incidents; and interactive/dialogic communicative approach in one incident.

8.2 Learner competences, classroom discourses, routines, and interactions

As discussed in the sub-sections of section 8.1, Nkoe's lesson on the concept of Perimeter was structured such that it followed a unique sequence of events which were led by him as the teacher. These events included: the introductory section where learners were given instructions on the practical outside-activity; teacher's explanation and examples on Perimeter; learners' activity from the textbook as practice of what had been exemplified; and teacher's group-to-group monitoring to ensure uniformity on solutions. All these activities were undertaken to prepare learners for a problem-set session where they were eventually given sheets of a problem-set to which they were ordered to find solutions.

8.2.1 (Episode 3, Lesson 2) Learners' competence, discourses, interactions on Perimeter – Perimeter as a function of Length and Width (2L+2W)

To carry out the exercise in the problem-set, each group of learners began by reading the problem-scenario in the sheet. In one particular group, four learners, Ts'epo, Mary, Tsire and Tumelo, sat together to read the scenario. Ts'epo and Mary read the scenario together while the other groupmates listened silently. However, the reading task was very short, followed immediately by the two learners brainstorming on which sides of the polygon were the length and width, hence relating them to the computational procedure or formula for Perimeter (of a rectangle) (See the extract below).

> [*Mary and Ts'epo are holding the worksheet and read through it together. The other two members, Tsire and Tumelo are listening closely*]
> **175: Ts'epo** (*reads*): "The diagram shows part of the yard where Mr. Stue keeps his sheep." He keeps his sheep here. The yard [*He shakes Mary to look at the diagram*]
> **176: Mary:** Oh the diagram! [*Points at the diagram*] here... This is the length. [*Mary points at the side labelled "12m"*] we have to find this… which means this plus this plus this [*points at the side labelled "5m" along with two other short equal sides and the "13m" side also*] …This is meters not the centimetre. The Perimeter is it's…it's metre or centimetre.

The group's decision to answer the question by calculating the Perimeter — even though the problem did not specifically state 'Perimeter') — could be related to the problem the teacher provided before the exercise that required the Perimeter to be calculated. The learners could not be considered to have confidently interpreted the scenario and related it accurately to the taught concept of Perimeter, hence indicating some incompetency resulting from the non-conceptual teaching they had received.

In their discussion on the interpretation of the problem scenario, though they had already been told they have to calculate Perimeter, it became hard for the group to locate the dimensions (or their magnitudes) of the polygon to use. This was observable when one learner, Ts'epo, tried to measure the lengths of the unlabelled sides of the shape in the diagram. The question the learners were trying to answer demanded them to identify the remaining unlabelled sides of the five-sided polygon, then use them to calculate its Perimeter. The measuring was not required since the figure was not to scale and the learners had to use their understanding or prior knowledge of properties of regular and irregular polygons. The following extracts shows the learners' deliberations as they struggled to find the magnitudes of the sides of the polygon to use for calculation of its Perimeter.

177: Ts'epo: No! [*He says as he puts a ruler on the diagram, measuring the length of the side originally labelled "5m." After measuring the length of this side with a ruler, Ts'epo also measures the length of the next short side with a ruler along with the last short side]*
178: Tumelo (*to Ts'epo*): They are not supposed to be measured.
179: Ts'epo (*after measuring*): yes, this one is half. [*Ts'epo points at the side labelled "12m"*]

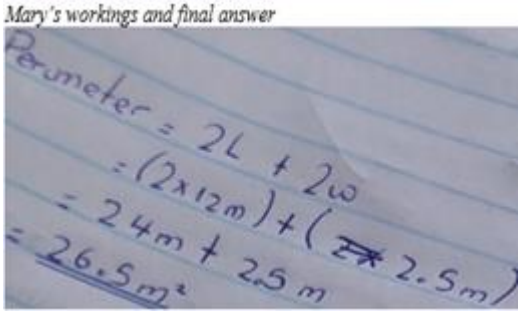
Ts'epo measuring sides with a ruler



The learners' argument on whether to measure the sides could be seen as their lack of understanding of the properties of a regular polygon or the concept of Perimeter in general. After the measuring option was rejected by the group, Mary, one of the groupmates, wrote down the 'previously taught' formula for the Perimeter of a rectangle, and substituted some of the sides of the polygon. The group's discussion around their written workings was never about the dimensions and formula used to get to the answer, which indicated that they considered their work accurate (see the extract below).

[*Mary writes the formula and workings*]
180: Tsepo: length and half…
181: Tsire: Two-point-five
182: Mary: It's two-point-five. [*Mary continues her workings*…No, it's not that small; you know why? This is a short length. The two sides are not the same [*points at the side labelled "13m" and the short unlabelled side*]

Mary's workings and final answer



183: Ts'epo: Twelve times two, twenty-four… plus two-point five.
184: Tsire*: No, are you supposed to write squared?*
185: Mary: This is a right-angle… a right… [*She says this pointing at one of the three major triangles on the diagram, which contains the "12m" side*]
186: Tsire: Right triangle.
187: Mary: Right-angled, it's a right-angled triangle.

For this part of the lesson, Ts'epo's group had a task to read the problem scenario and the subsequent question; interpret them; relate it to the taught concept of Perimeter; identify the dimensions of the polygon to use for calculation of its Perimeter; come up with an appropriate computational procedure or formula; hence use the procedure to solve the given problem. However, due to the ritual nature of the teacher's instructional practices, the learners used

memorised formula ($P = 2L + 2W$) and the information provided by the teacher prior to the exercise (that they had to find Perimeter). This indicated that their routines were dependent on the given formula which they could not selectively and appropriately apply. Their struggle therefore was to find the sides of the polygon (irregular five-sided) which they could substitute for length and width in the formula. This therefore showed that their routines were purely rituals.

As their further display of ritual routines, the group attempted to read the scenario however, they never attempted to interpret (that is, whether the question demanded them to find Perimeter or Area) since they had already been told what to calculate and given the formula they had to use. As such, their major activities involved trying to use the taught formula; accurately follow the computational procedure (multiplication by 2 and addition of the products); and writing down the correct units for Perimeter. The group also tried to measure the sizes of the sides of the polygon, an action which could have been instigated by the prior practical activity they performed at the beginning of the topic.

Though their discourses were mostly colloquial (with mathematical jargon including computational process and units, and some other out-of-concept discussions), the routines of interpreting the scenario and deciding on the computational procedure were mostly dependent on their teacher's prior explanations and examples which were still written on the board. In addition to these, and based on the engagement activities of the learners shown in several parts of their discussion, this group could not be regarded to have displayed the expected problem-solving skills. They also showed lack of understanding of properties of regular and irregular polygons since they failed to identify equal sides. They further indicated their lack of understanding of the concept of Perimeter since to them the given formula was the only way to find it, and their discussion never involved definition of Perimeter or any analogical connection that was cited by the problem-scenario.

As his regular monitoring duty, teacher Nkoe visited Ts'epo's group to check on their progress. In his discussion with the group, he realised the learners' difficulty to decide on which line in the given polygon could be used to calculate its Perimeter. To provide them with a hint to remember what Perimeter is, he used the 'food-inside-the-body' analogy, hence emphasised that Perimeter is everything outside the shape. However, no hint was provided for a computational procedure or formula to use. As of direct instructional nature as it was, the

teacher's hint seemed to have reminded the learners the definition of Perimeter. This was visible when later the group repeatedly pointed at the lines making the Perimeter of the shape while they discussed in order to decide on the computational procedure to use (see the extract below).

> **188: T3 (*to the group*):** Yeah? [*He looks at what they've written and laughs a bit*] Two length, two widths – where do we talk about that? …When we have the rectangle. [*Members listen carefully to what T3 says*] Perimeter is the distance around the shape.
> **189: Mary:** Ooh! Yes! Yes! Yes! [*She points at the diagram in the worksheet*]
> **190: T3:** Distance around the shape. Do we care about what is inside?
> **191: Mary:** No sir.
> **192: T3:** Yeah, nobody cares about what you've…eaten this morning, right? We care about you. [*Mary cancels what she'd written for question 1(a) and starts afresh as T3 leaves*]

In this extract, the teacher realised the learners' error of using the formula for the Perimeter of a rectangle on a 5-sided polygon. His scaffolding in trying to help the learners correct their workings was direct and teacher-dominated. He mostly focused on telling them that the formula they had used applies only on the Perimeter of a rectangle, hence he tried to show them that they had to take only the lines which were on the boundaries of the polygon not running inside. This therefore reflected his ritualised teaching approach since no explorative probing towards learners was provided by the teacher. By using the idea of food that learners had eaten, the teacher tried to provide an analogy that would help them understand that Perimeter does not have anything to do with the inside things of a polygon but the outside. This therefore indicated his link-making to support knowledge building: analogical link-making. Throughout this conversation, the teacher did most of the talking while the learners only responded to his leading questions with short responses and no argumentative elaborations on their workings. Therefore, the teacher deployed an interactive/authoritative communicative approach.

In their brainstorming, in search of the computational procedure to use, the group frequently referred to what their teacher had told them when reminding them of the definition of Perimeter (see extract below).

> **193: Mary:** So, Perimeter equals to…. Are these ones okay like this? [*Mary points at two slanting sides of the triangle on the polygon*] This one?
> **194: Ts'epo (*to Mary*):** Sir said around the Area.
> **195: Mary:** Yes, around this Area. [*Mary moves her pen around the same triangle*] this is where he keeps his sheep. Then these two sides…

As presented in this extract, the learners' conversation indicated that the teacher's explanation was memorised such that it hindered their creative thinking around the problem given or the

concept of Perimeter since they had already been told to calculate it. It also indicated that their substantiation as the teacher's explanation could not be considered an exploration but rather a ritual routine, memorised to be used in an attempt to identify the lines that form the Perimeter of the polygon.

Once again, teacher Nkoe visited the group to check on their progress, hence noticed their difficulty coming up with the correct computational procedure. He therefore probed to help them remember the definition of Perimeter while relating it to the problem-scenario in the problem-set. In his probe he guided them to point on the diagram, the lines which form the Perimeter of that shape, which they successfully did. Even so, they were still not probed to help them decide on the appropriate computational procedure. Rather, the emphasis was on them remembering the definition of Perimeter by referring back to the analogy of 'food-inside-the-body' while Perimeter is outside. The learners' responses in this session were enabled by the teacher's leading questions. These responses included agreeing or not agreeing with the teacher's leading statements (see the extract below).

> [*T3 gets to this group once again*]
> **196: T3:** We said Perimeter it's around the shape, isn't it?
> **197: Members:** Yes, sir.
> **198: T3:** So… that means outside the shape. Show me outside the shape.
> **199: Mary:** Sir it's here. [*She moves her pen around all the five outer sides of the polygon*]
> **200: Tsire:** Sir, did this question say Mr. Stue keeps his sheep here? [*Tsire points at the side labelled "12m"*]
> **201: T3:** Yes… Yes, right! That's what we're saying – this is why when you ask, 'how are you?' We look at your face. Do we look at what you have eaten?
> **202: Members**: No sir.
> **203: T3:** Yeah, that is the Perimeter – outside. Anything inside does not count; we've just written that now. [*T3 leaves*]

In this part of the lesson, the teacher intervened by directly telling the learners that Perimeter means outside of the polygon. They were guided with questions to identify the lines that form the Perimeter of the polygon. These questions did not demand learners' substantiation on their responses, hence the teaching routines were rituals performed to lead them to identify such sides to use. Once again the teacher reminded the learners of the idea of 'food-inside-the-body' as an analogy to intensify his explanations. This therefore, indicated his link-making to support knowledge building: analogical link-making. The interaction between the teacher and the learners could be seen as interactive since the learners were involved by responding accordingly to his leading questions. Their communication was also, to some extent, dialogic

since they took part by asking questions for clarification, to which the teacher responded accordingly. Thus the interaction involved an interactive/dialogic communicative approach.

To further indicate the inadequacy of their teacher's scaffolding, the learners in this group proceeded to brainstorm on the appropriate computational procedure to follow which did not relate to the teacher's reminder on the definition of Perimeter. Instead, the group were held up at the use of the length and width, and the related formula (taught) for the Perimeter of a rectangle (*Perimeter = 2L + 2W*). This was observed when they struggled to brainstorm on which lines on the diagram the length and the width were, and at times height and base. To be more accurate, their discussed formula, or its related length and width, was inappropriate for the current given polygon and for the given problem (see the following extract).

> **204: Ts'epo:** Length times two. [*Ts'epo says pointing at the side labelled "5m"*]
> **205: Mary:** Length times two? This is length right? [*Pointing at the middle shorter side*]
> **206: Ts'epo:** Yes.
> **207: Mary:** And?
> **208: Ts'epo:** Base.
> **209: Mary:** And this is height. [*Mary points at the side labelled '12m"*]
> **210: Ts'epo:** All of these are what? Height? [*He points at the three outer shorter sides*]
> **211: Mary:** I think if we can say this width, [*she points at the right-most shorter side*]. This is height. [*Points at the unlabelled longer outer side*] This is length. [*She points at the unlabelled shorter middle side.*] … And this…this thing… this shape has five sides, right? It has five. Five sides.
> **212: Ts'epo:** It's Length Times Width…
> **213: Tsire:** No, Perimeter is not that; it has to be equal to the length, plus width.

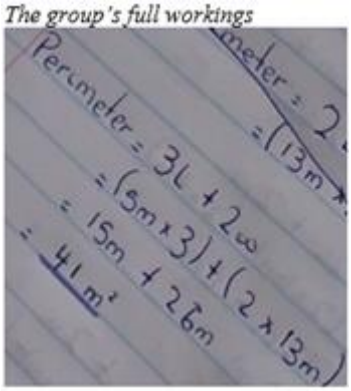
The learners' struggle to identify the 'length and width' of the polygon showed their lack of understanding of the concept of Perimeter. It also indicated their dependence on the taught or demonstrated formula which they never understood where and when (appropriate examples) it was most applicable, or where it cannot be applied (non-example). This therefore indicated their ritual routines. As they deliberated on their difficulty, their routines showed that they considered Perimeter as that formula (*Perimeter = 2L + 2W*), and the only way they could find the solution. This could have been instigated by the way they were introduced to the computational procedure as this formula, and the idea of a site as a rectangular shape. Throughout their confusion, the learners in this group could be heard uttering words related to the formula, hence their discourse was mostly colloquial though inaccurate.

At last, the group used the incorrect idea of length and width, but they correctly identified all the lines on the polygon which make up its Perimeter (including equality of lines). Coincidentally, the group used the formula and they obtained the correct answer. To get to this, they changed the formula into *Perimeter = 2L + 3W*, to accommodate the characteristic

property of the given polygon (2 sides equal and 3 others equal on their own), hence correctly substituted the sides accurately into their adjusted formula. This therefore got them the accurate answer, which they could have got if they had applied the correct computational procedure (of adding all sides) (see extract below).

214: Tumelo: It's three times length times two…
218: Mary: I think this is length, [*Mary points at the side labelled "5m" **and** another short one next to it*] also this is length. [*She points at the last right-most short side*]. This is width. [*She points at the two outer longest sides; one labelled "13m"]*. If then this is six, *[she points at the right-most shorter side*] This is three, right? [*The "12m" side has divided the base into two equal sides – Mary points at one of these halves*] So it should be length… two times length plus three times width.
219: Ts'epo: Yes.
220: Mary: Three times length plus two times width. It's fifteen meters plus…
221: Ts'epo: Twenty-six
222: Tsire: Equals to… it's eleven…
223: Ts'epo: Forty-one. [*Mary completes the workings and writes the final answer*] Yes, we are correct.

The group's full workings



The learners' incorrect and persistent use of the formula (2L + 2w, of rectangle) and adjusting it to fit the current irregular polygon (which was not a rectangle) was an indication of their inability to deviate from the use of the taught formula yet they could not identify where the formula was appropriate. This was also a display of learners' performance of the computation and rote use of formula (as demonstrated by the teacher) without any understanding of the concept under discussion, hence a ritual routine. Learners also showed dependence on the memorised formula for Area of rectangle without any relation to the concept of Perimeter or its definition, thus their operational strategy was mostly superficial. In addition to the ritual nature of their routines and superficial strategies, the learners' routines in this section of the lesson did not display any problem-solving skills. Though their routines were rituals, learners talked of the formula as a structure to use for obtaining the correct value for the Perimeter of the polygon, hence their structured discourse. Their talk over the use of their formula and the arithmetic operations thereof, showed that they consider the formula and the arithmetic operations as existent on their own as opposed to consideration of them as personally performed for existence. Though it seemed coincidental, the learners' discourses in this part of the lesson could thus be considered structured and impersonalised, hence objectified.

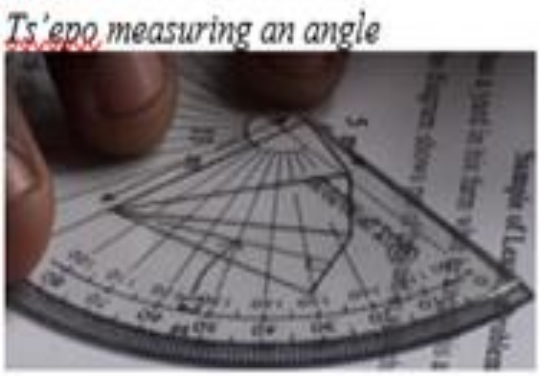
8.2.2 (Episode 4, Lesson 2) Learners' competences, routines, discourses and interactions on concept of Area

While working on the given problem-set, learners in each group eventually got to the question which requested them to calculate the Area of the whole 12-sided regular polygon. However,

as per the provided information, the diagram showed only a certain part of the polygon, hence the learners needed to read the scenario, interpret and relate the diagram to it and the given problem. Through this sequence of activities, they were expected to come up with (and successfully execute) the appropriate computational procedure and provide an answer to show their understanding of the concept of Area of a regular polygon.

For this section of the data presentation I concentrate on activities of one selected group, Ts'epo's group. In this group, the groupmates seemed to have started brainstorming on the computational procedure while concurrently trying to interpret the problem-scenario. In their struggle to agree on the appropriate computational procedure, the group kept hinting on taking half of one side taking it as the 'length' of one of the triangles in the diagram. The group further struggled to find the appropriate sides to use as 'length' and 'width', and to agree on the procedure to use in calculating the required Area. In their discussion, they seemed to remember something about what they were taught in identifying these sides. Their memory reflection included spotting the 90 degrees sign, hence using those sides which form it as 'length' and 'width'. Their struggle included trying to measure the sizes of the angles in the triangles to see if that angle was 90 degrees (see the extract below).

224: Ts'epo (*to members*): It is twelve times five.
225: Tsire: Two-point-five times twelve.
226: Mary: All animals... Why is it not five? Area of the yard occupied by all animals. [*She quotes from the question*]
227: Ts'epo: Do we look at the 90 degrees?
228: Mary: Where is the triangle?
229: Ts'epo: Here it is. [*Ts'epo points at one of the triangles from the diagram*]



230: Mary: For all… animals. This is where Mr. Stue keeps his sheep. We have length, [*she points at the side labelled "13m"*] and width [*points at the side labelled "5m"*]
231: Ts'epo: Oh this is the… this is the width? [*Ts'epo asks pointing at the side labelled "5m"*]
232: Mary: Right-angle it's only here [*points at the small right-angled triangle of height "12m"*]
[*Ts'epo takes a protractor and measures the angle in one triangle*]
233: Ts'epo: Here's the triangle.

234: Mary: We have only one right-angle there.

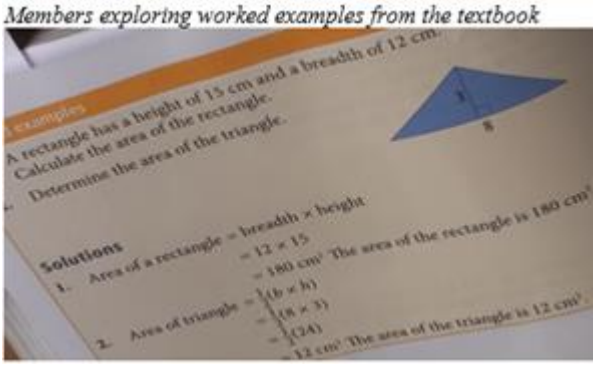
The learners' discussion here formed their colloquial discourse as they tried to interpret the diagram and identify the properties to use for calculation of the required Area. In their discourse, their target was to find the 90-degree angle sign they were told about, hence their routines were rituals since their focus on reading the scenario was soon stopped by their focus on the polygon hence trying to remember how to use the 90-degree angle sign as they were told by the teacher. This discussion also indicated the learners' dependence on the memorised idea of formula for the Area of a rectangle. This also indicated their lack of understanding of the concept of Area since they depended on the idea of 'length and width' to substitute into the formula which was explained to them during the teacher's presentation. Their discussion never involved any information in the problem scenario involving the animals and the yard. Therefore, learners never showed any problem-solving skills.

Eventually, when the group failed to reach any agreement on the procedure to use, one group member (Mary) complained that the teacher did not provide them with an example hence they were not able to solve the current problem. The group therefore decided to look up the examples in the learner's textbook. However, this action seemed not to have worked since it involved the geometrical jargon which was never introduced or explained to them by the teacher (that is, *Area of rectangle =breath × height; Area of triangle =1/2(b × h)*). As a result, learners in this group could not relate the operations in the example to the given diagram (in the problem scenario) (see the extract below).

235: Mary (*to groupmates*): Sir didn't write examples first. Let's see about two examples. Let's see. [*Members look for examples from the textbook*]

236: Tsire: Here it is! Wait. [*Members turn to a page showing worked examples on Calculation of Area*] Area of a rectangle… equals breadth times height! [*Tsire says as he points at the worked solutions*] it must be this one. We didn't have the breath and height…!!

Members exploring worked examples from the textbook



The learners' claim that the teacher did not provide them with an example, after failing to solve the given problem, was an indication of their dependence on the demonstrated use of formula,

and conforming to the teacher's demonstrated examples. This was further proven by their reference to the textbook for examples. Here they failed to get help because the same formula they were looking for was used with non-familiar terminology. Therefore, there was no familiar example to conform to in their operations, thus their routines were purely rituals. The learners' talk at this stage involved a few mathematical words, which did not refer to any conceptual understanding, and more words which were not mathematical. This therefore made the learners' discourse to be informal. Their reliance on the teacher's or textbook examples to try to compare to the problem indicated their lack of problem-solving skills.

8.3. Nkoe's responses to the Interview Questions - Teacher's understanding of his role

In this section, I present teacher Nkoe's responses to the interview questions. I also present the analysis on how these responses convey his understanding of the expectations of the curriculum and his role as a teacher in a learner-autonomous and active-learner-based mathematics classroom. In the extracts presented, Nkoe responded to seven main questions accompanied by some follow-up questions intended for further clarity and additional information. Each extract presents mainly the teacher's response to the question posed.

8.3.1. Question 1: How do you feel about the new integrated curriculum, and what are its main expectations, especially on the teaching strategies and learner's classroom behaviour and how do those compare with the old curricula expectations?

> **Nkoe:** *Yeah the curriculum is good but the problem is its structuring – they didn't structure it, they just put the syllabus there, and did not structure it in such a way that it can be able to interlink from level to level, and from topic to topic…So it needs one to sit down for a long time to structure it…till there is an order. Unfortunately, the expectations if you look at the syllabus and the way it is, its expectations from the students and teachers is just too high with not enough materials to go about.*

In response to the first question on curriculum structure and curricula expectations, Nkoe described the curriculum as not well structured in terms of topic and concept spirality. That meant he considered the curriculum difficult to teach since learners only see a concept once throughout the four years of secondary education hence all that needs to be done per topic has to be squeezed into one grade. He also described the curriculum as having too high expectations on learners and on teachers yet there were no resources available for them. He further commented that most learners show serious lack of understanding since the concepts are of a higher level than what the Grade 8 learners are able to handle, so the teacher takes more time

than is acceptable before the learners could understand. Hence, the teacher would prefer a more direct instructional approach to improve learners' understanding.

8.3.2. Question 2: What do you understand by active learning and teaching, and learner-autonomy in a mathematics classroom, and what role do you play in order to facilitate active learning in your mathematics classroom?

> **Nkoe:** *I think what they are trying to say is closely related to student-centredness whereby you create activities that the students can do and also the teacher as the facilitator but also facilitator in everything. That is in correcting whatever is about the activity itself, that sometimes the learners have come to up with their own ideas. So you have to be able to help them to learn by themselves…More especially I think it involves more research on both the teacher and the learners. …the major role of the teacher I think is as a facilitator…looking at what they get, and their results should also be reasonable. Sometimes you try and help them, correcting themselves, facilitate that they can be able to redirect their solutions from wrong to right. …sometimes you don't even have to show them that they're wrong…. Your role can also be let them present themselves. Each group presents, after the groups present they can also see, okay, we were going in this direction but these guys did it in the right direction. The major role of the teacher is to make sure that they start debate – the students themselves start the debate and arrive at a consensus.*

In this response Nkoe described active learning as learner-centredness where the teacher creates learners' activities. He described the teacher's role as facilitation of learning activities by allowing learners to come up with their own ideas and conduct some research; inspecting their findings and probing them to give reasons for their solutions or findings; and accommodating all their findings and try redirecting their results towards the correct conceptions. He emphasised that the teacher's role is not to tell learners that their work is incorrect, but allow them to present from their groups so that each group can realise their mistakes from other groups' presentations, and also start learners' debate on their presentations and let them arrive at their own collaborative conclusions.

The teacher provided some views on his role which indicate his instructional approaches as active, and his instructional routines as explorative, especially where learners are probed to substantiate their solutions or findings. These include: allowing them to research and bring new ideas to the classroom, inspecting their solutions or findings and probe to make them see their mistakes, while avoiding to do the telling.

8.3.3. Question 3: With your definition of learner-autonomy and active instructional approach to teaching and learning, how do you teach Mensuration to help your students comprehend the topic thoroughly?

> **Nkoe:** *Yeah, it's a process that cannot always be possible…At times they can be autonomous, you let them handle something, the research, depending on also the level of the learners is very important… their level of understanding, and their level of cooperation… also their social background because those will make sure that as the group… the groups can be functional. ... there are some classes whereby they are autonomous I'd say, the same approach, …Now, I simply gave them... usually I give them exercises to do after teaching, right? Then at some stage some guys said ache! You know those who are faster…, so I would try and give them some different questions and then I see that they do them, then I said "okay guys we are here, we cannot be able to grasp or do things in the same pace, so it's always nice for you, when you have learned something by yourself. …I let them do some textbook exercises, or past examinations papers on their own, and if they finished the topic they go to the next one. They just submit to me anytime and we discuss…to say now what have you done explain to me? Why do you think it is correct…?*

In this response, Nkoe defined learner-autonomy as a way of allowing learners to handle materials and do research; grouping them according to their level of understanding, and including their social background. He however believed that learner-autonomy is an impossible approach in teaching his learners. His expressed instructional routines as promotion of learner-autonomy included:

- giving learners an exercise 'after teacher's presentation';
- giving faster learners (on given exercise) some extra exercises while helping or waiting for slower ones to catch up; allowing learners to proceed working on the new topics on their own (in the form of working on the given exercises from the textbook) to promote LA;
- learners do some exercises on their own as part of their LA;
- allowing them to do some working on the past examination question papers of their choice and submit to the teacher for marking or discussion;
- they submit to the teacher anything they would have chosen to work on and the teacher asks them to narrate how they did the exercise, or choose the key words in the questions for learners to address;
- guiding learners to make them realise that their answers/procedures are incorrect and make them think about their approaches to the problem.

These routines indicate the teacher's diversity of instructional approaches. The routine of grouping learners and teaching them according to their level of capability and understanding, and providing faster learners with special exercises while helping the slower learners, indicates the use of differentiated active instructional approach. The routines include allowing learners to do some textbook exercises; working on the examination papers on their own and submit for teacher's approval; and probing them to narrate and substantiate their workings; and indicating an active instructional approach which is not authoritative on the side of the teacher.

8.3.4. Question 4 (a): In a learner-autonomous mathematics classroom, how do you approach different learning styles?

> **Nkoe:** *I'll be honest, it's very difficult. ... it simply depends on the situation because in some cases you try to think that now if this person cannot understand this in this way and that way how do I, Sometimes I don't find a solution to…getting an alternative way of approaching. Sometimes I start asking in order…I start with the line and then if you don't understand I say okay, now if you don't answer why didn't you ask because I said you should ask? …Okay you didn't ask, no problem, now tell me, what do you understand about what we're doing now? We're thinking about what we are doing now. So sometimes...each of them has to reason out how did I get the answer…?*
> *…Sometimes after they do the exercise I tell them to come with their books and then I could practically see them. … Because if we've done it twice it means now…away from the group you need to have this person as an individual and address his or her individual problem.*

In this response, teacher Nkoe showed his perception of the huge difficulty of keeping learners autonomous and active while catering for their different learning styles and the struggle to provide alternative approaches when learners show lack of understanding. He insisted that if only a few learners show interest in answering the teacher's questions, the questions should be posed to each of them on a rotational basis, even to those who do not show interest/effort to answer. If learners are reluctant to ask questions, the teacher could force the answer out of them by probing them to explain how they got their answers (in each group or individuals), so as to maximise their participation. He further suggested explaining slowly for those slow learners so that they understand or memorise the presented concept, and working with individual learners to address their individual problems.

The teacher's gesture of forcing uninterested learners to answer his questions, and forcing them to narrate their used procedures and substantiate them, is an indication of the teacher's authoritative yet less participative classroom environment. The idea of dividing learners according to their level of working pace; working closely with individual learners to address

their problems; and particularly explaining slowly to slower learners indicates the teacher's use of differentiated active instructional approach, though it may include some elements of direct instructional approach on the side of the slower learners.

8.3.5. Question 4 (b): In a learner-autonomous mathematics classroom, how would/do you encourage your students to express their creativity, and maximise participation?

> **Nkoe**: ...*although it cannot be in all topics, there are topics that you can encourage them, that you can be able to assign them to do certain activities that can… that are found in the environment. …some are things that can be done at home, you must also encourage them to do them outside the school. This I think should be the cornerstone of everything – they must be able to use social thing... the internet to find… to research on the internet. Anything that they can find and they can come and bring different approaches into the class.*

To encourage their creativity, teacher Nkoe claimed that he encourages his learners to use things available to them at home, use the internet and social media to do research as the basic learning tool, and he allow them to bring to class some different approaches. These ideas indicate that Nkoe ideally prefers integration of real-life objects and experiences with classroom-taught mathematics concepts which may involve active engagement of learners.

8.3.6. Question 5: What classroom practices do you think mathematics teachers should master in order to promote learner-autonomy and facilitate active learning in order to maximise learner conceptual understanding?

> **Nkoe:** *One is to take away the mathematics from being a subject, to having mathematics as life…. By always trying to show the relevance of what you're doing in class with what is actually happening in life, such that they don't just say "what is this Pythagoras? It's just a difficult name." It should be done with the purpose of showing what does this Pythagoras or where do we use it, or where do you the students think it can be used if you structure it such that the students can make the connection between what they have in class? That is the most important component that I think I want to see in a mathematics teacher. Two! I need to see mathematics teachers encouraging working together and coming up with solutions in cases like we can have eh… some sort of competitions among the students. If the class can be able to develop that attitude of competing in terms of participation, I think that would very paramount to having more improvement in the teaching of mathematics.*

For this question, Nkoe suggested some classroom teaching practices which he wished to see in a mathematics teacher. These include: teaching mathematics concepts with more emphasis on how they relate to the real life objects or activities, which is one of the most important practices by a teacher; encouraging learners' collaborative work and bringing some solutions

when they have arguments amongst themselves; and engaging learners in competitions while learning mathematics to increase participation.

These suggested practices indicate that Nkoe considered learners to be actively engaged and autonomous when they are taught through real-life concrete materials and experiences. He also believed that active engagement and learner-autonomy means learners have to work collaboratively and engage in activities which involve competitions. All these show that the teacher believes in active instructional approach as a way of teaching mathematics.

8.3.7. Question 6: How do you feel about the way you conducted the lessons, and to what extent do you think the learners were autonomous and actively involved in the learning processes?

> **Nkoe*:*** *…Well I don't feel well about the first part because...that's the part where they had to have the string around their rectangles, and squares because I could see that I didn't give specific instructions as to what they had to do with the string. So that was the part that I said okay, eh it wasn't that good. And also I think that… one other thing was that the connection between the string and now the actual lengths of the rectangle.*
> *In some cases, in fact, some of them already had made the conclusion about their previous knowledge that they simply said fifty times 2, what-what times 2…so that is why I wanted each one of them after finishing outside to get in, record their results...the length of their string…And then together with the length of their sides. So some when they got in they simply go to their friends. This one has 2L plus 2W…. And most of them had squares, but they didn't have squares outside…. So I think it needed more coordination, such that they needed them to have confidence to say what have I done? Is it correct or not?*
> *I think they were in a scale of about 5 because there they were very much active (on the outside-of-classroom activity), but as to the autonomy it wasn't bad, but like I said the problem that I created with not giving the correct instruction.*

In evaluating the lessons in which he was observed, teacher Nkoe highlighted a number of inconsistencies he experienced. These included: that the lesson was not well conducted as a result of not providing clear specific instructions to learners; learners had difficulty in making the connection between the used string and the length around the rectangle; learners came to the lesson with memorised(prior knowledge) formula (P = 2L+ 2W) of Perimeter for rectangle so could they not blend it well with the use of the string; learners' practical work outside the classroom could not be linked (by learners) with the actual concept of Perimeter to be taught in the classroom - learners copying or using memorised formula of how to calculate.

The teacher believed that if he could have provided a further elaboration on the instructions for the practical session, the learners would have performed the task more efficiently. This therefore indicated his preference for direct instructional approach. He also saw his learners as incompetent in making connections between the practical activity and the definition of the concept of Perimeter as a result of their memorised formula for the Perimeter of a rectangle, thus considering his learners to have relied on ritual routines. To further attest this incompetence and ritual routine performance, teacher Nkoe concluded that the learners needed to be taught or told what to do with the string measurements and what was to happen in the classroom, and that they held onto their prior memorised formula for calculation of Perimeter of rectangle (P = 2L + 2W) hence did not learn anything from the practical session. The teacher however, emphasised his use of direct instructional approach where he insisted making the learners to identify the height and base of a triangle by telling them to concentrate on any perpendicular lines in the triangle.

8.3.8. Question 7: What do you think was your role in this classroom during this lesson, and what was the learners' role, and what improvements would you do in your teaching approach to maximise active learning, promote learner autonomy and conceptual understanding?

> **Nkoe:** *My role was to check if there's any progress, because some concentrated on flattening the ground, which was not what I needed, so I had to tell them, "no man, no man it doesn't matter whether it is flat or not, just do it." And when I go check the others, no they continue with their flattening because there was a bit of misunderstanding that if you're talking about a site, it should be flattened so that you can build.*
> *So… my major role was to go check that each and every one of them is doing the right thing; … I should think the first part is that the instruction should be clear; … before we go outside, I need to do my own site then they come to the class so that I show them exactly how they're supposed to do it…, I show them this is my site, it has got this and that.*

While on the reflective part of the interview session, Nkoe described his role during the observed lessons as to move around the classroom to monitor learners' progress on the given task by directly telling them where they were incorrect and telling them what they had to do to get things correct. This included going around between groups to check if they were doing what they were commanded to do. This therefore indicated that he considered he should have practised some explorative routines intended to provide appropriate but minimal scaffolding for learners to be in line with the given task. He also laid his perception of learners' inaccurate performance of the given task and difficulty following instructions accurately on incomplete guiding instructions and planning. Therefore, for future lesson improvements Nkoe suggested

a number of instructional practices such as: before giving learners a practical task (marking and fencing of sites), the teacher should give clear instructions with an illustration with the teacher's own site; providing clear and detailed explanations and instructions for tasks; and having a thorough preparation of the learners for the types of questions in the problem-set by first teaching and practising them on regular and irregular polygons.

Most of the suggested future practices involve explicit explanations by the teacher and prior preparation of the learners for the next lesson. This further indicated the teacher's preference for the more authoritative teacher-led direct instructional approaches.

8.4. Summary of Nkoe's instructional approaches and data consolidation (interview responses vs observed actions)

Nkoe's teaching involved some practices classified as elements of active instructional approach. These included probing learners with leading questions to activate their prior (and common) knowledge on the concepts of polygons, their properties and related information in discussion, and trigger their thinking or suggestions on the new concepts, Perimeter and Area. These observed activities somehow came up in Nkoe's interview responses.

In the interview session, teacher Nkoe mentioned active instructional approach practices such as: defining active learning as learner-centredness where teacher creates learners' activities, and teacher's role as facilitating learning activities; and accommodating all their findings and redirecting their results towards correct conceptions. However, most of these uttered activities were not observed during Nkoe's teaching, except the part where learners were given a chance to work on the given activity and the teacher's role as facilitative by going through learners' work and probing to direct them to correct procedures or answers. Nkoe's utterances towards instructional practices in relation to learner-autonomy included: allowing learners to handle materials and do research; grouping them according to their level of understanding; allowing learners to proceed working on the new topics on their own; allowing them to do some working on the examination question papers of their choice and submit to the teacher for evaluation.

In response to a post-lesson evaluation question, Nkoe insisted that during his teaching, the learners were, to some extent, actively engaged throughout the lesson, especially on the out-side-classroom practical exercise. However, he claimed that his learners were not that much autonomous. Besides that, his instructions were not clear hence caused learners'

misunderstanding of the task. This perspective concurs, to some extent, with the observed learners' reactions during the practical activity. Further, in concurrence with the observed teacher's instructional practices, teacher Nkoe described his role, during learners' activity, as moving around to monitor their progress on the given task by directly telling them where they are incorrect and what they have to do.

In addition to the telling and explanations provided to learners, the uttered instructional practices in Nkoe's responses included activities of direct instructional approach. In response to the question on instructional improvements to maintain learner-autonomy and learners' actively engaged, Nkoe suggested practices including: performing a practical exercise as an example prior to learners' exercise (outside); preparing learners for the problem-set activity by practising them on regular and irregular polygons; and teaching learners with several examples of different shapes so that they are not stuck on the formula for Perimeter of the rectangle. These responses concur to the observed teaching practices which reflected Nkoe's appreciation of the use of direct instructional approach.

In addition to their observed use of mostly ritual routines, especially when working on the practical exercise, Nkoe accused his learners of showing lack of understanding since his instructions about the string were not clear. Besides the learners' conceptual inaccuracy, and his instructional approaches, Nkoe made several evaluative claims about the new curriculum in relation to the grade level of the learners and his prior capacitation as a teacher. In response to the question on his perception of the curricula expectations he declared it 'good', yet he claimed that the mathematics syllabus arrangement of topics lacked order, spirality and integration across grade levels, hence complicating teaching preparation. This perception could also substantiate the teacher's dominant use of direct instructional approach and learners' lack of understanding in most parts of the lessons.

Nkoe also claimed that the curricular expectations on teachers and learners were 'too high', and were not matched to the calibre and level of understanding of the learners for who it was implemented. He further insisted that the level of difficulty of the topics in the syllabus was too high to be understood by learners at Grade 8 level, hence it was hard helping them understand anything at all. This perspective of learners' lack of conceptual understanding, as a result of a high-stakes curriculum, could be the reason for the observed dominant direct instructional approach in his class. Though not all of these responses correspond to the

observed classroom activities, they have some importance to the present study since they could be indicative of the reasons that influence teacher Nkoe's choice of teaching approaches, learning routines, and perspective of learners' competences and their level of autonomy.

8.5. Conclusion

The presentation and analysis of data from Nkoe's classroom observations is presented in four episodes which cover the two lessons in which he was teaching concepts of Perimeter and Area. In the first episode, teacher Nkoe was observed using an active instructional approach in the introductory part of the lesson by exposing his class to a practical session. In that session, learners practically used their prepared equipment to try to learn the concept of Perimeter, though they did not understand the instructions and purpose of the exercise, hence forcing the teacher to provide a more elevated scaffolding to assist them to complete the session.

In the second session of the first episode (the inside-of-classroom session), and in the second episode, the teacher actively engaged his class by mostly probing to seek learners' suggestions on concept definitions, computational procedures and arithmetic processes. This was also observed when giving them exercises and a problem-set to practise the use of taught computational procedures or formulae. However, in all these activities, the teacher's interaction with the learners was more authoritative and meant to strictly direct them to conform to the given formulae.

However, in the same sessions, the most dominant teaching approach observed in Nkoe's class was direct instructional approach. In most incidents, Nkoe provided the learners with definitions, explanations for each new concept, derivation process of the formulae, and provided worked examples to demonstrate the computational procedures for Perimeter and Area of different polygons. In each case, the examples were followed by a similar-characteristic exercise given to the learners to perform the demonstrated procedures as a way to apply the knowledge just acquired. They were also given a prepared problem-set to work on as some way of assessing their understanding and competence on the taught concepts of Perimeter and Area. To confirm the learners' answers and procedures correct or incorrect, Nkoe would mark with a tick or provide an authoritative probe followed by further explanations if the answer was incorrect or procedure not well used.

Since in most parts of the lessons the proceedings were dominated by the teacher's unidirectional presentations, which involved actions of direct instructional approach, the teacher-learner discourses were mostly formal. These discourses were mostly about the definitions of the concepts of Perimeter and Area, their computational procedures or formulae, and arithmetic processes that go with the use of the formulae in worked examples, and on the problem-set. Due to the formal nature of the teacher's presentations, his discourses were mostly objectified except in rare cases where he explained some procedures and formulae to correct learners' answers/workings as they worked in groups. The learner-learner discourses on the other hand involved informal and colloquial discourses as they discussed the problem scenario, brainstormed on the properties of the polygon, and deciding on the appropriate formula to use for calculations, and the arithmetic processes as they executed their calculations.

From the beginning of each lesson, teacher Nkoe's instructional routines mostly involved direct reminders on properties of some polygons in focus. These reminder sessions were executed as ways to get learners started on the learning process on the new concept of either Perimeter or Area. However, the presentations were done without expression on the purpose or substantiations that could be related to the concept yet to be taught, hence qualifying his teaching as purely ritualised. These ritual teaching routines were further observed throughout the lesson presentations, which involved: direct introduction of new concept by telling the definitions; providing and deriving the formulae while telling strict rules on what to use or what not to use (for instance, half-length times width, instead of half-base times height); providing textbook worked examples to demonstrate rote use of the formulae; giving learners a problem-set to work on as a way to practise the rote use of formulae; and monitoring learners' progress by telling, explaining and demonstrating the correct way of doing the activity or arithmetic process.

All these were mostly geared at helping learners to memorise the new definitions, formulae and their rote use, without substantiation on selection of appropriate situations where each formula is most applicable or how they could be used connectively to solve real-life problems. The learners therefore were mostly relying on the memorised formulae and struggled to use them, and even used them where they were not applicable, hence they were using dominantly ritual routines, instigated by their teacher's dominant ritual teaching routines.

In several parts of the two observed lessons, the teacher produced the majority of the link-making explanations, with a few instances where learners were guided through leading questions to produce such explanations. All the link-making explanations were produced as a direct instructional approach to support the knowledge building hence trying to instil understanding of the two concepts, Perimeter and Area. The links made were:

- link-making to support knowledge building - making links between scientific explanations (concept of Perimeter, its scientific explanation and definition) and real-world phenomena (idea of length of a fence around the site);
- link-making to support knowledge building - making links between scientific explanations (concept of Perimeter and its definition) and real-world phenomena (the distance walked around the site or length of fence around the site);
- link-making to support knowledge building - making links between scientific explanations (definition of concept of Area) and real-world phenomena (the space enclosed by the fence of a site);
- link-making to support knowledge building - making links between scientific concepts (Concept of Area as space enclosed by Perimeter, and concept of Perimeter as a boundary of Area);
- link-making to support knowledge building - making links between scientific concepts (Area and Perimeter of a rectangle); and
- teacher's link-making to support knowledge building - analogical link-making (dividing rectangular land into halves by diagonal, share a half for a Son) in three incidents.

Throughout the observed lessons, the teacher-learner interactions involved three forms of communicative approach, each at a certain frequency. These were: interactive/dialogic communicative approach in three incidents; non-interactive/authoritative communicative approach in two incidents; and interactive/authoritative communicative approach in 14 incidents. As demonstrated, the interaction predominantly involved interactive communication yet was authoritative by the teacher, which included link-making explanations which were dominantly produced by the teacher.

This observation ,in addition to dominant ritual performance, largely disobjectified colloquial discourses, and visible learners' incompetence , advance and substantiate the contention that

the classroom environment in Nkoe's class did not create opportunities for learners to be autonomous as they developed their knowledge of concepts of Perimeter and Area.

Chapter 9: Data Presentation and Analysis 4 – The Case of Pita's Class

9.1. Pita's Instructional Practices

This section presents teacher Pita's instructional practices as observed from his classroom teaching. These are presented in two episodes which are titled according to the teaching activity observed. The classroom environment created and monitored by the teacher is described by the diversity (or lack thereof) of instructional approaches, types of discourses and routines, and interactions involved in teaching the concept. In each episode, the data is first presented as extracts from classroom discussions, as it sequentially occurred in each lesson, followed by the analysis.

9.1.1. (Episode 1: Lesson 1) Teaching Perimeter of Quadrilaterals and triangles

Pita's lesson on Perimeter concept began with the teacher's probe to activate learners' prior knowledge on length, its units and instruments. After his probe-explanation-and-example presentation on length, teacher Pita introduced the concept of Perimeter as a function and abstraction of the length concept by direct telling. He probed learners to mention any type of a 2D shape to activate their prior knowledge, which learners managed to mention (see the extract below).

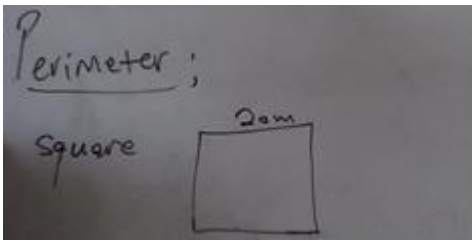
> **T3:** Length, yes. … I doubt this is the first time you see the word Length?
> **Learners in a chorus:** No sir.
> **T3:** What does it mean? Can anyone describe it for us?
> **L1:** Is the distance from one point to another.
> **T3:** Ok. …the idea of length brings us to what we call Perimeter. Do you know anything about shapes? What shapes do you know?
> **L1:** Square!
> **L2:** Triangle.

In this introduction, the teacher's involvement of learners through question-answer interaction indicated his active instructional approach in activating learners' prior knowledge of length and types of 2D shapes. The communication in this part followed an interactive/authoritative approach since the learners were given a chance to talk back, yet the talk did not allow them to raise their opinions but respond to the teacher's leading questions.

He proceeded by reminding the learners of the equal-sides property of a square as an example of a 2D shape. This reminder serves as link-making between the length and the concept of Perimeter.

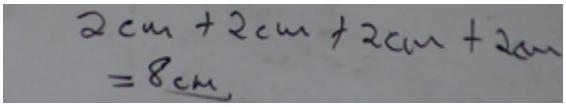
However, the teacher did not give learners an opportunity to make that link, as he quickly explained and demonstrated, with an example, how the Perimeter of the square was to be calculated (that is, the add-all-sides procedure). While writing the workings and final answer on the board, the teacher asked learners what the answer was (after writing it on the board), hence an easy answer from the learners. The teacher's example was followed by a summarising definition of Perimeter as an affirmation of the demonstrated computational procedure.

What T3 has written on the board



T3: We say that for a square all the sides are equal, right?
Learners in a chorus: Yes, sir.
T3: Okay. If we have a square of 2 cm side that means we have 2cm here, here and there, isn't it? …We say mathematically a Perimeter of this square is 2cm added to this 2cm added to this one and that one. So we add four 2cm, right?
Learners in chorus: Yes, sir.
T3: And what do we get?
Learners in a chorus: We get 8 cm.

T3's written calculations

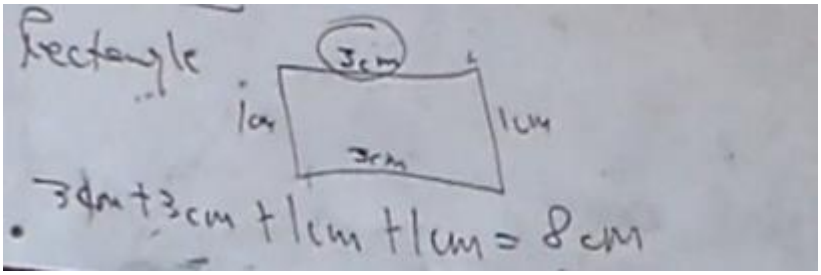


In this part of the lesson, the teacher engaged learners in a ritual routine, as he explained and worked out the Perimeter of the shape without involving the learners in some substantiation. The ritual routine is also shown by personalising what the process ("…*this brings us*; *we have a rectangle*…'') hence their disobjectified discourse. For this presentation, Pita demonstrated the procedure by explaining while writing the workings on the board. Since this process was unidirectional and learners were only superficially involved, it qualified his instruction as direct approach. In this extract, learners took part in the conversation by providing responses to the teacher's leading questions, hence the conversation was interactive/authoritative.

As the next step, the teacher drew a rectangle and told the learners about its parallel-equal-sides property, and asked them to calculate its Perimeter as a way of practising the computational

procedure he had just demonstrated. Following the command, the learners started working on the problem. A few minutes later, the teacher demanded each group to provide their answers. As they tried responding, he probed those who provided the answer to narrate the computational processes they had followed to get answers. One learner narrated their computational process, and the teacher showed approval of the answer and procedure by repeat-and-expand practice (Teacher repeats learner's correct answer and expounds with explanation to make it clearer to the class). In his expansive explanations, teacher Pita included the parallel-equal-sides property of the rectangle as a reminder and logical reasoning for the correctness of the followed procedure and answer (see extract below).

T3: What do you get?
Learners: 8cm.
T3: How did you get 8cm?
L1: 3 plus 3 equals to 6, 1 plus 1 equals to 2.
T3: So we add 3… plus 3? ...Oh and this one is 3cm and this one is 1cm? Because it's a rectangle isn't it?
Learners in a chorus: Yes, sir.
T3: Two sides that are parallel are equal, and the other two are also equal, isn't it?
Learners in a chorus: Yes, sir.
T3: Okay that means we will have 3cm and we will get?
Learners in a chorus: 8cm.
T3: 8cm, that is a Perimeter.
T3 's written calculations



Learners were given an opportunity to utter their answer and narrate the procedure they had used, and their accuracy was evaluated using the demonstrated procedure. This could be regarded as an act of active instructional approach. However, the active nature of the activity did not last long since the teacher took over the platform with repeat-and-expand practice which made learners to become more passive with their led responses, including '*yes sir'* response to '*akere*?'[right?] confirmatory.

The teacher posed some leading questions including '*how did you get it?*' which demanded learners' narrate the procedure used. However, this questioning did not demand learners'

substantiation on choices of procedures. This thus indicated Pita's ritual performance. This was further displayed by the teacher-learner personalised and processual discourses hence disobjectified. His leading questioning was about the addition process learners performed to obtain the answer 8. This indicated that the value 8 depended on their addition process. The teacher's questioning allowed learners to only provide their answer and narrate their followed procedure, hence the communication involved an interactive/authoritative communicative approach.

The teacher further ordered learners to work on the exercise in the textbook. He then went on to probe the class for their answers on the exercise. He moved between groups inviting alternative answers, at times approving their answers correct by saying '*okay*'. In this activity, the teacher's prolonged probing occurred mostly when the learners' answer was incorrect, or when they uttered decimal numbers inaccurately. This was done to make them aware of errors and hence lead them to utter and write the correct answer (see extract below).

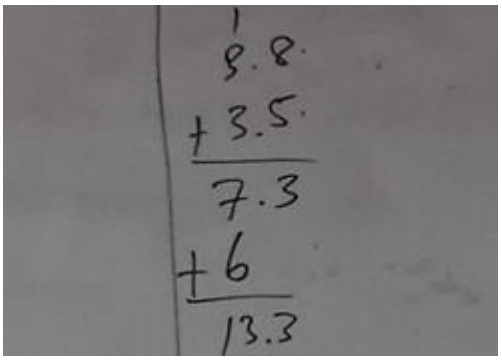
T3: What do you get?... Twenty-four?
L: Twenty-five.
T3: Twenty-five? Add correctly.
L3: Twelve-point-thirteen sir.
T3: Twelve point thirteen?
L3: Yes, sir.
T3: Do we call it thirteen?
L3: Yes
L4: No… twelve-point-one-three sir.
T3: Yes.
T3 (to another learner): What do you get?
L5: Sir zero.
T3: zero!?
T3 (to L6): What did you get? *[Moves from learner to learner looking into their exercise books and asking what answer they obtained]*
L6: …Thirteen-point-three.
T3: Oh, okay.

Here the teacher persisted in engaging learners actively in the practice of the add-all-sides procedure by allowing them to provide their answers. Since the learners were probed to provide their answers and the teacher provided scaffolding to allow them to realise their mistakes, the talk involved numbers hence their discourse could be tagged colloquial. However, the teacher's questioning did not demand learners' reasoning on their answers, hence indicating his ritual performance. The teacher's probe and the learners' comments on their incorrect answers steered other learners towards providing correct answers, thus helping their peers to rectify their mistakes.

Since he probed learners on specific point of view, which was their computed Perimeter, the conversation was interactive/dialogic.

When realising the learners' uncertainty and inaccuracy on the addition process and resulting answers, the teacher called the class to attention and demonstrated the addition process while leading with confirmatory questions. Though the main target was to obtain the Perimeter of the given shape, the presentation was focused on the addition process on decimal numbers. To make the process learner-engaging, the teacher used some rhetorical questions which showed learners that the process was not over yet so that they could come up with more suggestions. The teacher ended the discussion by posing a question to check the number of learners who performed the addition process correctly and obtained the answer similar to his (see extract below).

T3: Let's see… attention…we have three-point-eight, isn't it?
Learners in a chorus: Yes, sir.
T3: Okay what is eight plus five?
Learners in a chorus: Thirteen.
T3: That's thirteen, do we put thirteen down?
Learners in a chorus: No sir.
T3: What do we do?
Learners: We put three and carry one.
T3: We put three and carry one, and then what do we do next?
Learners: We put a decimal point, then we add three plus one.
T3: Three plus one that's four, then?
Learners: Plus, three.
T3: What do we get?
Learners: Seven!
T3: We get seven. Are we done?
Learners in a chorus: No sir.
T3: What do we do next?
Learners: Plus, six.
L1: Sir we put a decimal point between thirteen and three.
T3: Between thirteen and three? Like this?
Learners in a chorus: Yes, sir.
T3: So… what do we get in the end?
L2: Thirteen-point-three.
T3: Yes.
T3's complete calculations



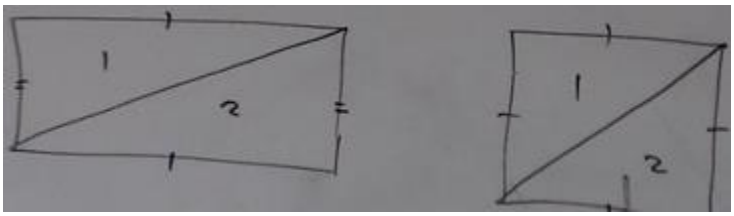
T3: Who got thirteen-point-three? ...all of you?
Learners: Yes, Sir we got it.
T3: Okay, let's pass on…

In this extract, the discussion was mostly on the arithmetic process of adding decimal numbers. Though the learners seemed to have correctly memorised the add-all-sides computational procedure for Perimeter, the discussion on the exercise took much of the lesson time since most learners were showing difficulty with the addition process. This therefore indicated their lack of arithmetic manipulation skill. The teacher actively engaged them with an exercise to work on as practice and conformation to his demonstrated procedure. He also performed the computations, and posed leading questions (including the *'how'* question which demanded learners to narrate the computational procedure they used) and provide their final answers. This questioning did not require them to substantiate their use of procedures but reiterate the procedures. This indicates the teacher's instructional routine as a ritual. The ritual performance was further displayed by the personalised and processual discourses hence disobjectified discourses.

9.1.2. (Episode 2: Lesson 2) Teaching Area of a triangle as a function of Area of rectangle

The lesson on Area of a triangle began with the teacher drawing a rectangle and square and reviewing their properties. He then cut the square with a diagonal line and probed learners to show them that the diagonal divided the square into halves which are triangles. The same discussion was conducted with the rectangle (see extract below).

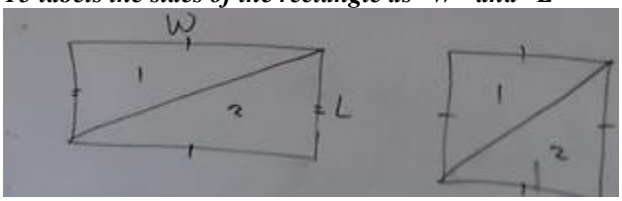
T3: Is part one and part two equal?
Learners: Yes, sir
T3: And this is equal to that, isn't it? [*T3 points at the other two shorter sides of the rectangle*]
Learners: Yes, sir [*T3 draws a diagonal line across the rectangle and labels the two portions "1" and "2"*] are they still equal?
Learners: Yes, sir.
T3 has divided the rectangle and square with diagonal



Though the teacher's presentation on the diagonal relationship of rectangle and triangle involved some leading questions, the overall presentation was mostly authoritative and directly providing information through explanations and illustration on the diagram. This therefore indicated a direct instructional approach. Though the learners were allowed to talk, they were just answering the teacher's questions with a *"yes*". Since they were not given the opportunity to voice their opinions, this indicates Pita's communication as interactive/authoritative. This questioning – which requires learners to give a confirmatory "*yes*" answer – qualifies classroom practice as ritual.

The introductory probe was then focused on the computational procedure for Area of a rectangle. In ensuring activation of the prior knowledge for the whole class, the teacher probed for accuracy in identifying and labelling 'length and width' of the rectangle (see extract below).

T3: Now, let's talk about this; how do you find Area of a square or rectangle? I know you have done it.
Learners: "No sir," "Yes sir,"
L1: Sir length times width.
T3: Length times width. So here which one is length which one is width?
L2: The upper side is width.
T3: This one is width? [*Writes 'w' next to the upper side of the rectangle*] So which one is length?
L2: The short one.
T3 labels the sides of the rectangle as "W" and "L"



T3: So, you say Area is equal to length times width?
Learners: Yes, sir.

This process of activating learners' prior knowledge mostly involved teacher-learner question-answer discussion, hence it kept most learners actively engaged. The teacher asked them whether they knew how to calculate Area, and L2 explained how it was calculated and indicated they identified the sides of the diagram. This shows that the classroom interaction was dialogic. The classroom discourse has characteristics of ritual, as the teacher did not inquire learners' understanding on why the Area is calculated as they narrated.

After probing to convince the learners that the diagonal cuts the rectangle into halves, the teacher explained and demonstrated that the Area of each triangle is the Area of a rectangle divided by two or multiplied by half (see extract below).

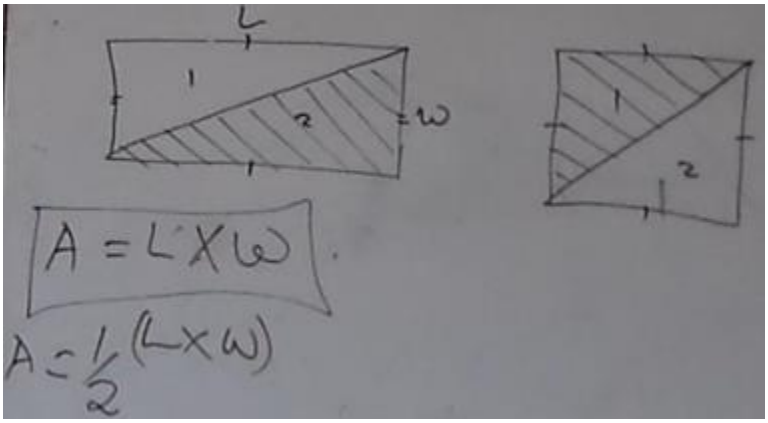
> **T3:** Length times width. *[Writes: "" below the rectangle*]. So if this is half, if these sides are equal then this is half of the whole rectangle, do we agree?
> **Learners:** Yes, sir.
> **T3:** So we take... we take Area of a rectangle and we divide it by two, isn't it?
> **Learners:** Yes, sir. *[T3 writes ")"]*
> **T3:** Then we get the... Area of this triangle, right? *[T3 points at the shaded triangle*]
> **Learners:** Yes, sir.

For this part of the lesson, the teacher engaged direct instructional approach as most of the activities were done by him to introduce the computational procedure for Area of a triangle. The conversation involved a probe which was authoritative, intertwined with thorough explanations on properties of the two quadrilaterals to activate learners' prior knowledge. The teacher's talk was personalised as he used personal pronouns hence disobjectified discourse, and indicative of ritual performance. His ritual performance was further indicated by direct rejection of the learners' inaccurate responses on the computational procedure for Area of triangle and little focus on the meaning of the concept while focusing on their understanding of the procedural steps followed. Though the learners were kept participative by frequent leading questions, the questioning was more authoritative and led by the teacher to direct them towards the expected responses, hence interactive/authoritative communication.

As continuation of the lesson, to ensure learners master the use of the formula, Pita asked if they understood. Instead of their usual response of '*yes sir*', some claimed to have been *'lost*'. To address the issue, the teacher re-narrated the procedure on how the cutting of the rectangle by diagonal formed two similar triangles which become halves of the rectangle. However, yet more learners claimed to '*still be lost*'. In trying to further address the issue, the teacher re-narrated the procedure of cutting the whole shape into two equal triangles. However, this time the teacher used the drawn shapes on the board by shading and pointing at them as he explained (see extract below).

> **T3**: Do you understand? It's like some of you are lost.
> **Learners:** Yes, sir!
> **L4:** We're lost.
> **T3:** We have a rectangle, isn't it?
> **Learners:** Yes, sir.

T3: We split it into half. …when we split it into half, we get ... two triangles, isn't it?... And because we have split it into half the Area of one triangle will be half of the whole rectangle, is that so?
L5: Yes, sir.
L4: Sir I am still lost. Is that the answer?
T3: The answer to which question? Let's talk about this; we split this into two isn't it? That means this part, [*points at the upper triangular portion of the square on the board*] the first one, [*shades this triangle*] is half of the whole square, is that so?
Learners in a chorus: Yes, sir.
T3 has shaded halves of the two shapes.



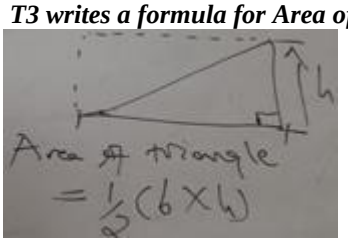
T3: We split it into two equal parts, the triangle on top is half of the whole square, and the triangle at the bottom is also half of the whole square. Area of this triangle down here it's equal to half Area of this old rectangle. [*Points at the shaded triangle drawn inside a rectangle*] is that so?
Learners: Yes, sir.

In this section of the lesson, Pita used unidirectional presentation in addressing learners' difficulty, indicating the use of direct instructional approach. The teaching routine of rote repetition of the derivation process of formula for Area of a triangle from that of a rectangle indicated ritual performance. This is qualified by the fact that he described how the Area is calculated without giving learners the opportunity to figure it out by themselves. He only engaged them in confirmatory questioning which required a "*yes sir*" answer, which qualifies his communication as interactive/authoritative.

Following the repeated explanation on the development of a new formula for triangle, the teacher immediately provided the generalising statement on the computational procedure and formula for Area of a triangle. In his presentation, he made learners aware that the formula applies to all right-angled triangles and demonstrated how to identify a right-angled triangle. The presentation included introduction of the new terminology, base, and height (see extract below).

T3: That means any right-angled triangle… we say it is a right-angled because at the corner here we have a 90-degree angle.
T3: ...will always be part of a rectangle, we understand each other, right?

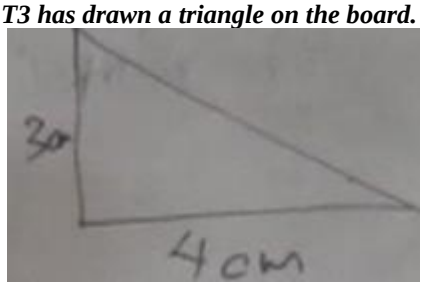
Learners: Yes, sir.
T3: So, to calculate Area of a triangle it will always be half… we call this one the base from here to here, this line we call it the base of a triangle and from here to here, it is the height isn't it?
Learners: Yes, sir.
T3: Just like you, from your feet to your head that's your height, isn't it?
Learners: Yes, sir.
T3: So this is how we find the Area of triangle.
T3 writes a formula for Area of triangle



The transition from the formula $Area = \frac{1}{2}(L \times W)$ to the new formula $Area = \frac{1}{2}(b \times h)$ was not made explicit to the learners and no probing happened, hence no substantiation was provided for the use of base and height in place of length and width or how the new formula relates to the concept of Area. This therefore showed the ritual performance by the teacher. The explanation of height was also done through the spread-legs analogy. This indicated the teacher's link-making to support knowledge building: analogical link-making. Throughout this presentation, the teacher used direct instructional approach since the learners were only involved by posing an '*isn't it?*' question to which they responded with a *'yes sir*'. Since the learners were involved through a confirmatory answer only, this indicates that the classroom was interactive/authoritative.

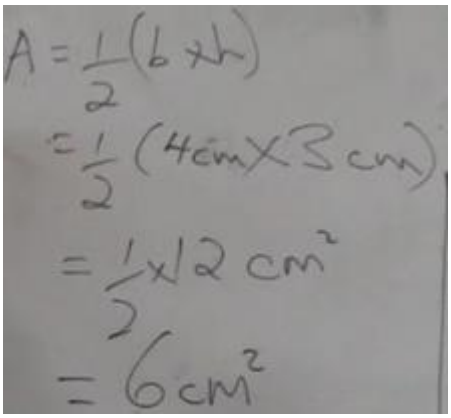
This was then followed by the teacher's worked example while guiding the learners with leading questions through the computational process. In this example, Pita began by reminding them the new formula (). He then probed them to identify the sides to be substituted for base and height in the formula and led them through the arithmetic computation to get the correct answer (see extract below).

T3: Let's make an example. …
T3 has drawn a triangle on the board.



T3: Let's calculate the Area, right?

Learners: Yes, sir.
T3: We will say the Area equals half base times height, isn't it? ...Now, this is half... what is base? [*Learners do not answer*] how long is the base?
Learners: 4cm
T3: 4cm ... times height, what is our height?
Learners: 3cm.
T3: What is 3 times 4?
Learners: 12.
T3: It is now 12 square centimetres, but we are still multiplying by half, right?
Learners: Yes, sir.
T3: Okay what is half of 12?
Learners: 6
T3: The Area of that particular triangle is 6 square centimetres, isn't it?
T3 has written calculations



Though the work in the example was done through teacher-learner probing, the probe was non-interactive and authoritative since it was unidirectional from the teacher accompanied by a concluding summary of the procedure. This therefore, indicated the teacher's use of direct instructional approach. His demonstration of how the new formula worked was executed by showing the learners how to identify the height and base of the triangle and how they are substituted into the formula and the rote computation process. This was only to help learners to memorise the formula and dimensions, without any suggestion or probe for alternative approach, reasoning or how it relates to the given definition of Area. This therefore indicated the teacher's ritual performance.

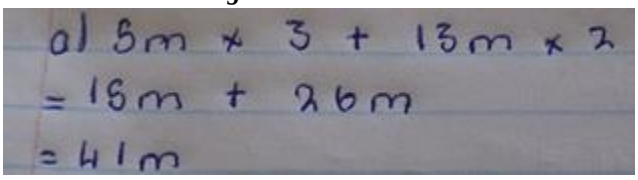
9.2 Learners' competences, classroom discourses and routines

After a presentation on the Perimeter of different types of polygons, teacher Pita ordered learners to work on the part of the problem-set which required calculation of Perimeter. Learners struggled to read and interpret the problem-scenario, hence struggled to come up with a suitable computational procedure for the required length of *'fence'*. In their discussion, they showed no

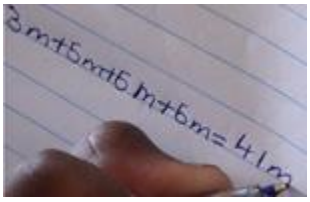
reference to the procedures they had just practised or the examples demonstrated to them by the teacher prior to the problem-set.

After some time, with the learners struggling to interpret the problem-scenario while trying to come up with the appropriate computational procedure, the teacher provided some interpretation of the scenario. The interpretation involved showing them the equal sides of the polygon. The group proceeded with a discussion, and seemed to have remembered the properties of the regular polygon which allowed them to identify the sides of the polygon which were equal. They then performed multiply-by-number-of-sides (for the equal sides and added the products), and add-all-sides procedures to find the required Perimeter. In their workings, they correctly applied both procedures and agreed on the final answer (see extract below).

Thato: 5 times 3 and 13 times 2…then 15 plus 26 …is 41, isn't it?
Neo: 41 yes
Nthati: 5m times 3…
Nthati writes workings and answer



Neo: But then if I made it like… look 13m plus 13m plus 5m plus 5m plus 5m equals 41m.
Neo writes answer after adding sides



The group showed some understanding of the properties of the regular polygon and had accurately memorised and applied the two procedures after being reminded such properties. This indicated that their competence was raised by their teacher's scaffolding. However, their routines and discourses on the calculations had no reference to the problem at hand, hence this indicated that their performance of the procedures was done as a practice or proof of procedural knowledge just explained to them by the teacher. This thus indicated their lack of problem-solving skills which would help them make connections between the procedures to perform and the problem-scenario.

The learners' routines in this part of their discussion were rituals since they had little substantiation over their choices of the computational procedures and of the polygon sides to use. For instance, Nthati (one of the learners) used the multiply-by-number-of-sides procedure combined with addition of the products as an alternative to add-all-sides. However, she never defended her choice or reasoned to convince groupmates why the procedure was correct. As much as their routines were not explorative, the learners' discourse, as they worked through the arithmetic process in the procedure, were, to some extent, objectified since they talked of the answers 26, 15 and 41 as sums of the subsequent sides of the polygon, not as processes that occurs through their personal actions of adding.

While working on the problem-set, the group began to discuss the next question which demanded calculation of total Area of the *'yard*' (the 12-sided regular polygon). In this discussion, the group seemed to have no knowledge of the concept of Area and hence kept brainstorming on what procedure to apply and what units of Area are. Their discussion indicated their difficulty in interpreting the problem-scenario and locating part of the *yard* which forms the Area where *animals are kept* as stated in the question. Since the discussion was a brainstorming session in the concept of Area posed in a real-life problem scenario, learners' discussion had no direction and hence the discourse was colloquial. The group eventually surrendered due to their difficulty and decided that the '*teacher will come to explain'*. This indicated their dependence on their teacher's explanations and demonstrations of the working procedures, hence their ritual performance (see extract below).

> **Thato:** Why did you multiply? Why did you multiply that by four?
> **Neo:** Oh! Yes! And here is Area, the answer of Area is squared.
> **Thato:** Squared?
> **Nthati:** Squared… How?
> **Neo:** Guys, no, it's cubic!
> **Nthati:** Cubic? That's not!
> **Neo:** Is squared…This is a mark it shows that we're gonna multiply. [*Neo points at the marks [3] allocated for question (a)(i)*]
> **Thato:** So why are you saying cubic? So how are you going to find that Area there where he keeps his animals?
> **Neo:** Where is the animals here? [*Neo points into the diagram*]
> **Nthati:** We don't know, may be sir will come explain to us.

While on this brainstorming session, some groupmates insisted that whenever the question says *Area* they need to use '*Length times width'*. However, this idea was quickly abandoned and the

group went on trying to relate the words in the problem-scenario. The group eventually admitted to be having a problem and surrendered and claimed that the teacher would have to come to explain to them (see extract below).

> **Neo:** Area… we should multiply length times width...
> **Nthati:** Okay I see!
> **Katleho:** The yard has it's... column of sheep, sheep.
> **Neo:** Then?
> **Katleho:** Then it's sheep, sheep, sheep. [*Points at the three triangles on the diagram, in which the sheep are kept*] It's the yard…
> **Neo:** Did they say… there?
> **Katleho**: No, they just said twelve-sided regular polygon.
> **Nthati:** Okay so we have to…
> **Neo:** Why aren't they making squared over all of these things because here we are calculating Area?
> **Nthati:** Ninety-eight. Ninety-eight.
> **Thato:** And it's like; we're going to find the…
> **Katleho:** Ahh!
> **Neo:** I don't understand.
> **Nthati:** ...yoh! Sir… it's like we have a problem. Sir will come and explain for us.

In this brainstorming, the discourse involved mathematical words and words from the problem-scenario (for example, yard, sheep, Area, twelve-sided, regular polygon, calculate) yet there was no structure or any endorsed narratives or any indication of understanding of the problem. The learners' discourses therefore were mostly colloquial and indicated their dependence on the teacher's authoritative interventions hence their ritual performance.

9.3. Pita's responses to the Interview Questions - Teacher's understanding of his role

In this section, I present Pita's responses to the interview questions. I also present the analysis on how these responses convey his understanding of the expectations of the curriculum and his role as a teacher in a learner-autonomous and active-learner-based mathematics classroom. In the extracts presented, Pita responded to seven main questions accompanied by some follow-up questions. In each extract I present mainly the teacher's response to the questions posed to him and, in some instances, follow-up questions are presented.

9.3.1. Question 1: How do you feel about the new integrated curriculum, and what are its main expectations, especially on the teaching strategies and learners' classroom behaviour and how do those compare with the old curricula expectations?

> **Pita:** *…I feel like … it's premature. …they rushed into things, looking at material done by the Form 1* (Grade 8) *up to Grade 10. It's very disappointing because they drop some of the topics too early, at Grade 9, then now the learners will never see those topics again until in the examination. And the problem is that they rushed everything and took all the content and put it in one place and now it ends there. Some of them I saw they end in Grade 10, they are not there in Grade 11.*
> *…in terms of teaching strategies they expect us to be less of ourselves and more of the students. They expect us to guide students through certain things, they expect them to discover these things all by themselves but if you look into it, this syllabus is not that different from the IGCSE. Until now we have to tell them that 'no, this thing is like this,' and then it kills the whole thing.*

In this response, Pita considers the Grade 8 mathematics syllabus as a mismatch to the learners' level. That is, the level of difficulty of the topics is above the learners' level of understanding and the topics lack spirality which would gradually introduce learners to topics in accordance to their difficulty level. This perspective therefore, could be decisive on the teaching approaches Pita used which formed part of the classroom environment he created as he taught.

In relation to the teaching strategies and learners' behaviours, Pita interpreted the curricular expectations as demanding learner-centred strategies which include learner-hands-on activities. This therefore indicated that he considered the expectations as creating and monitoring an active and independent-learner classroom environment. However, Pita believes the content in the syllabus to be similar to the content in the IGCSE syllabus, hence learners were unfamiliar with the concepts and therefore forcing teachers to use direct and teacher-dominant strategies which made the classroom environment to be more passive and teacher-dependent.

9.3.2. Question 2: What do you understand by active learning and teaching, and learner-autonomy in a mathematics classroom, and what role do you play in order to facilitate active learning in your mathematics classroom?

> **Pita:** *Well, I normally tell my students ahead of time what we are going to do and I tell them my expectations that 'no, you need to go out and read and take any information wherever it is that you can get it – either from the old books, from the internet or you can ask anyone.'…And I believe given the expectation that they have in this curriculum, I think that's what should be done. It gives the learners a sense of belonging, that the information that we're going to talk about it's something that they knew prior to the class.*
> *…my understanding of it is that we should take the mathematics from the abstract view and now try to turn it into something more practical. I think that's what they mean by active approach. My role in that kind of a classroom is to be an overseer. … some sort of a leading role whereby my*

work is just to guide, to overview everything they do so that each and every step that they take or a process they undergo, they're just explaining to me.

In his response, Pita defined active instructional approach as the teacher's way of making mathematics content less abstract, making teaching to be more practical/involve practical activities. He further described it to involve making reference to other real-life things. In recognition of this description, it suggested that his usual instructional practice was to begin by ordering learners to take some home-work or carry out some research, or read some material from any source prior to the lesson. He further substantiates his claim with the reason that that way, learners gain membership in the mathematics community and relevance of the concept in their real-life. Though Pita's response implies a favourable perspective of active instructional approach, indicating an outside-the-classroom method which could not be observed.

Pita's utterance of his role as a leader, listener, and overseer, indicated his understanding of his role as a facilitator of learners' active activities. This uttered role however, involves the teacher's demand for learners to narrate the procedures they used, without a probe, to provide appropriate reasoning/substantiation for such procedures. This therefore indicates his routines as rituals.

9.3.3. Question 3: With your definition of learner-autonomy and active instructional approach to teaching and learning, how do you teach Mensuration to help your students comprehend the topic thoroughly?

> **Pita:** *…well there is an expectation and then there is a reality…. And the reality somehow is different from the expectation. Yes, we expect students to go out, get the information and carry out their own experiments if need be. We tell them to do that, we expect them to do that but they just don't do it in a way that is expected of them… It means before we proceed now I need to explain this thing, and even go to the extent of telling what was expected of them, what the students discovered, so that we can move to other things.*

In response, Pita described this concept as mere expectations which are far from being equal to the real activities related to classroom teaching and learning. This was substantiated by describing his learners as incapable of doing activities independently hence, as a teacher, he always had to resort to activities of direct instructional approach. This therefore indicated Pita's adherence to the

ritualised teaching routines and more direct instructional approach practices as opposed to curricular expected learner-autonomy.

9.3.4. Question 4 (a): In a learner-autonomous mathematics classroom, how do you approach different learning styles?

> **Pita:** *Well, you see with the learners they learn better when in a group with other students where they engage in these types of activities together, and then I get to realise that. I just put them in that situation. But for those that I realise that no, these ones their only problem is time, you just give them time and everything will come to them and then I get more time with them in their own group…. And those that will learn by actually finding things themselves I create some sort of problems for them that will actually guide them into using that discovery method where I guide them with questions and in the end I ask questions that will actually show them that 'no, what we have been doing just above we've been discovering this thing and that one.'*

To this question, Pita claimed that he uses differentiated teaching approach to cater for learners who learn better in group settings, and individualised teaching approach to accommodate slow learners by allowing them time to catch up, while providing fast learners further problems to work on. He also indicated that he used discovery method in his teaching. As he described his teaching approaches, his emphasis somehow indicated that he preferred explorative teaching routines to address learners' different learning styles and paces.

9.3.5. Question 4 (b): In a learner-autonomous mathematics classroom, how would/do you encourage your students to express their creativity, and maximise participation?

> **Pita:** *…well, I think the best thing with a matter of expression is about creating environment for students such that they should feel like they don't need to impress anyone, or such that they feel like even if they get it wrong it's fine. My best work is trying to always make sure that no, they shouldn't be afraid of being wrong or even looking stupid for that matter. … students are very full of themselves, they just don't want to look stupid in front of anyone…So you create…an environment that is good enough for them to express their feelings and the creative part comes just as a bonus, where now we do things and we actually do them together as a class, and for everything that we are trying to do we try to find a positive side of it – then everyone would be encouraged to express whatever they want to express in any way that they want to do it.*

Pita's response claimed that to facilitate learners' creativity, he made them feel independent, and not perform their learning processes to please the teacher or anyone else but they should value the experience they bring into their learning processes. He insisted that the teacher should create an

environment that allows the learners to express their feelings – creativity follows this kind of environment. He also insisted that the teacher should treat learners such that they do not fear getting things wrong or look stupid when they provide incorrect answers during their learning. He further suggested that learners should be allowed to do things together to achieve common specific objectives — hence the success will motivate them to do more.

These responses indicate that Pita holds the perspective that learners could better express their creativity when working in a learner-autonomous environment, where they work independently and are allowed to pursue explorative learning routines. He also believes that they learn better when they work together in collaborative discussions.

9.3.6. Question 5: What classroom practices do you think mathematics teachers should master in order to promote learner-autonomy and facilitate active learning in order to maximise learner conceptual understanding?

> **Pita:** *I think this one I'm not sure if it's a practice or what but creating that teacher-student relationship; if it is good then definitely that kind of a teacher will have the best class with regard to this learner-autonomy. …you see the relationship between a teacher and a student, not just one student but a general student in the class…it is how you create a very good environment for teaching and learning of mathematics.*
> *I actually think it's a two-way street whereby we say; now towards this kind of a relationship what is the teacher's input and what is the student's input? But also taking into mind that the student' input is actually dependent on the teacher's input. So if he creates the environment, if he initiates the relationship then the students will now be automatically into this thing of active learning.*

Pita's response to this question brought in an uncoded aspect of a good teacher-learner relationship, which he described as advantageous to promoting learner-autonomy. He further suggested that the teacher needs to create good environment for teaching and learning of mathematics. Though Pita did not provide any further elaboration and substantiation for his suggestions, he showed that he believes learners' active learning and autonomy depends heavily on the teacher's instructional practices and the status of his relationship with them. He indicated this in his concluding statement in the above extract. This perspective indicates that Pita believes, to some extent, in learners' dependence on their teacher's routines which denies them an opportunity to execute any learning strategy on their own, hence a perspective which is more ritual based.

9.3.7. Question 6: How do you feel about the way you conducted the lessons, and to what extent do you think the learners were autonomous and actively involved in the learning processes?

> **Pita:** *…well it was out of nowhere, and it was a race against time, and obviously I didn't get to finish. I would have loved to cover everything and I'm just happy that my students seemed to be excited and they were engaging in a way that is positive towards everything….*
> *…going around and talking to them, some of them were not actually trying their level best. They were just there expecting me to now come to them and try and help them out with everything while some of the students were actually trying, and without me coming to them they were getting everything right. To me it says that with the first part of the presentation, they actually listened and they took that and put it into practice, into something that I did not even express that much and they were able to do it. I think that is part of the active learning but some of them were just there and expecting me to come and guide them through every step that they must take…. And to me it says that's just fine.*

On this self-reflective part of the interview, Pita had the perception that though his learners were excited during his teaching, he was not able to implement all the work he had planned due to shortage of lesson time. He also concluded that his learners showed 'positive engagement' *(which could mean they responded accordingly to his given commands or tasks)* towards all lesson proceedings. He concluded that the learners were neither fully autonomous nor fully actively engaged in their learning activities. He substantiated the latter utterance by stating that a few learners were actively involved and working independently as expected while the majority were not active and not even trying their best to understand; rather they expected the teacher to explain each and every step they were supposed to take to work on the given exercises. This therefore indicated that he considered his learners' routines as mostly rituals since they depended on their teacher's routines and explanations.

9.3.8. Question 7: What do you think your role was in this classroom during this lesson, and what was the learners' role, and what improvements would you do in your teaching approach to maximise active learning, promote learner-autonomy and conceptual understanding?

> **Pita:** *The first thing that actually needs to be improved is the classroom setting, because I realised that in their own groups, the fast learners were with the fast learners and other ones who are actually a bit slower, were just there by themselves. So that way the teaching and learning process is very slow.*

Then the other one would be my presentation of things. I think the order was fine but the extent to which I was explaining some of the things to them I think it was not quite well or quite appropriate given that in this particular lesson I did even tell them what we are going to do…that they should read about or ask about or research about. So part of my presentation, is about that research that I told them to go and do. So if I was to do it again now I would actually tell them what to do, what to research about so that when we come to class we just listen to what they have to say and explain a few things, correct a few mistakes and then go on with the lesson.

As he put it, Pita's role during the lessons was to: allow learners to explain the procedures they followed to come up with their answers and listen to them and provide corrections and explanations for the correct answers. This indicated that though the teacher allowed the learners' to actively engage in their learning process, he was still authoritative and using direct instructional approach practices by providing explanations to learners when they got answers incorrect instead of probing to allow them to figure out the correct answer by themselves.

Pita believed that he needed to improve the classroom setting in terms of arranging the learners in their groups. This he attested by pointing out that fast learners in each group were dominating the discussions hence the slower learners were just following the work of the faster ones. As a way to further mitigate this learner-inequality and promote the learners' active engagement, Pita suggested a rather improved classroom setting, including selection of learners for each group, and providing them with clear guidelines for any learning activity, including activities prior to and during the lesson. This indicated Pita's belief that for learners to be actively involved, the teacher has to create an environment where everything is made easy for them. This therefore indicates a more direct instructional approach which involves more teacher guidance which is, to some extent, ritual-based.

This perspective was further confirmed by Pita's explanation that to improve his teaching, he needed to explain thoroughly in his presentation to make the learners get the concept of discussion. This included giving them clear guidelines on what to research prior to and during the lesson.

9.4. Pita's data consolidation - interview responses vs observed actions

As displayed in each of the extracts in all the episodes, learners were exposed to several activities classified either as direct or active instruction. Some of the actions that are labelled as active

instruction do, somewhat, concur with Pita's uttered teaching practices gathered from his interview responses.

Pita reported his understanding of the expectations of the curriculum, on teaching strategies, as learner-centredness of the instruction and independent learning. In a talk over his own teaching strategies, and however contrary to his observed teaching practices, Pita claimed that he always began his lessons by giving learners homework, ahead of the lesson, in which they do some prior reading on the topic. He insisted that that way his teaching becomes easier since the learners get a sense of belonging, and during the lesson he corrects and talks about something they are already familiar with. To further demonstrate this perception and active perspective of the curricular expectations, Pita described active instructional approach as a process which involves practical work and learner-autonomy having to do with learners doing information search prior to lessons, and conducting experiments on their own.

However, he described these two concepts (active instructional approach and learner-autonomy) as mere expectations which are far from being equal to the real activities related to classroom teaching and learning. This was substantiated by describing his learners as incapable of doing activities independently hence he always had to resort to direct instructional approach. This perspective, to a degree, concurred with the observed classroom actions in which he began lessons with an active instructional approach (for instance, probing to activate learners' prior knowledge) and resorting to direct instructional approach when they show incompetence. This was also observed where learners were given an activity to work on and provide their answers and the procedures they had used, failing which the teacher resorted to direct telling.

In addition to his perspective of active instructional approach, Pita described his role, in an active and autonomy-oriented classroom, as an authoritative overseer or supervisor of the learners' progress when given a task to perform in their groups or individually. He described this supervising as involving stimulating conversation between learners and probing them to explain their procedures as they work. This perspective indicates Pita's philosophy of teaching as involving some elements of direct instructional approach and authoritative ritualised practice. This was in concurrence to his observed actions where, after giving learners an activity, he moved among

learner-groups to authoritatively probe for their answers and procedures and providing explanations meant to assist learners to get correct answers.

In the reflection part of the interview session, Pita assessed his learners at half-scale in terms of their active and autonomous participation and competence. He argued that some of them showed lack of active participation and competence in problem-solving, hence expected him to explain the problem and provide procedural solution. He implied his learners' ritualistic behaviour when arguing that only the fast and brilliant learners showed some expected engagement. Pita's perception –,of his learners as incompetent and dependent on his direct instructional activities –,was further affirmed by his strong suggestion that to improve the situation, he needed to provide more explanations and a clearer guide to learners.

The latter perceptions align with the observed classroom activities, especially during the learners' group discussions on the exercises and problem-set. In those cases, learners successfully worked on the exercises that demanded rote use of a procedure that was demonstrated to them by the teacher through examples. However, they failed to interpret a problem-scenario related to the taught concept of Perimeter hence had difficulty identifying the correct solution procedure. As a result, learners resorted to waiting for the teacher to provide an explanation and the procedure to use.

9.5. Conclusion

For all the data presented, the most dominant teaching approach observed in Pita's class was direct instructional approach. In most of these cases, he provided learners with explanations for each new concept, provided worked examples to demonstrate the computational procedures for Perimeter and Area of different 2D shapes. In each case, the example was followed by a similar-characteristic exercise given to learners to perform the demonstrated procedures as a way to apply the knowledge just acquired. In some instances, the exercises were varied according to level of difficulty to allow the learners to have a rote practice on the procedures.

Though the teacher-learner discourses were, in rare instances, informal, there were predominantly colloquial discourses, as a result of dominant practices of direct instructional approach. These discourses were mostly about rote explanations on the processes learners had to follow to find

correct answers (processual discourse) while using the procedures, and the teacher's talk was personalised (personalised discourse), thus dominantly disobjectified discourses. In addition, the teacher's presentation on the procedures for each concept was a way to enable the learners to follow the procedures. There were no attempts to help them make connections between concepts/sub-concepts, and the discourses lacked activation of learners' logical substantiation for the use of such procedures. These aspects therefore indicated Pita's instructional routines as rituals. This way, learners were exposed to a classroom environment which offered them limited freedom or diversity in their acquisition of new knowledge.

In general, Pita's teaching was not without incidents related to the active instructional approach. He made several attempts to activate learners' prior knowledge by question-answer method and gave learners opportunity to work on the examples as a class. He also gave them a chance to work on the exercises and problem-set as a way of practising/applying the demonstrated procedures. However, his major role during these activities was mostly authoritative probing to make learners narrate the procedure they had used. This therefore indicated learners' knowledge confinement to teacher's explanations and demonstrated procedures.

Furthermore, the teacher's role in the groups was to authoritatively probe learners to seek their narration of used procedures, and provide explanations with correct answers to show them that their workings were incorrect. This indicated that Pita's instructional practice was to ensure learners follow and replicate what was explained and demonstrated to them, without provision of substantiation or deviation from the rote procedures. As a result, this further proves Pita's ritualised instructional routines. His instructional practices therefore suggest that he persistently created and led a classroom environment which hindered learners' autonomy.

In most cases, the learners' discourses were on the computational process (for example, addition of decimals and two-digit numbers) with little focus on the concept to be learned, Perimeter, hence colloquial discourse. Though learners' discourses were, in very limited instances, formal and focused on mathematics, they were mainly on the addition process (processual discourse) and mostly personalised (personalised discourse), while most of their discourses were colloquial. These discourses were therefore disobjectified hence indicated the learners' ritual routines.

The teaching involved direct instructional approach hence learners routines included: passive listening and copying teachers examples; rote practices in using the given procedures while working on the exercises similar to the demonstrated examples; providing the teacher with answers and narrating used procedures without substantiation for their choices; failure to interpret and relate the problem scenario to the concept of Perimeter; and dependence on the teacher's examples and explanations to solve problems. These actions therefore indicated the learners' routines as rituals. In addition to ritual routines, learners showed lack of problem-solving skills and incompetence in the comprehension of the concept of Perimeter (for instance, their inability to relate the 'total length of the fence' to the concept of Perimeter; and failure to identify sides of the polygon to use in the formula for calculation of Perimeter).

Pita's uttered understanding of curricula instructional expectations involved inclusion of learner-centred, active teaching approach, and learner-independence. However, he considered his role as an 'overseer' for all classroom activities. He described his role as supervision which involves: moving around among learners' groups to see how they are progressing with a given exercise; probing them to 'explain' their workings procedures; and showing them where they are incorrect. This therefore, to some extent, does not describe him as a facilitator as advocated by the curriculum. He further explained that since learners show incompetence and struggle to perform the given tasks on their own, he is compelled to resort to direct instructional approach. He also considered his learners not active and independent enough hence requiring him to resort to direct instructional approach.

There was minor concurrence between the observed instructional practices and Pita's uttered practices. He reported his role as an 'overseer' for the learners' progress, and the role he played during the problem-set session reflected him as more of an authoritative supervisor than a facilitator. There were misalignments between his responses and the observed instructional practices. Some of his response indicated that the curriculum expects the teaching to be learner-centred, promote learner-autonomy and always involve active instructional approach. He also insisted that his role has to be that of a facilitator where learners are allowed to do more work than the teacher. However, his observed instructional practices mostly involved direct instructional

approach which engaged the teacher more than the learners and created a teacher-dependent learning environment. This could be concluded as a misalignment between teacher's uttered knowledge of what he is supposed to do and observed teaching practices where he is seen as incapable of implementing it or hindered to do so by some obstacles, such as mismatch between curricula difficulty level and learners' level of comprehension.

Chapter 10: Thematic Presentation of the Findings

10.0 Introduction

The study collected data from four mathematics teachers who were observed while teaching in their actual classrooms and were later interviewed. The observation included a focus on learners' small group discussions as they worked on given Mensuration-related problems. This was to address the study's purpose which was to explore the nature of classroom environments these teachers created as they teach concepts of Mensuration, as a response to curricular expectations directed at implementing the LAE-oriented curriculum. The study therefore, focused on: the pedagogical practices - which included teachers' preferred instructional approaches, discourses and routines, teacher-learner communicative and pedagogical interactions; learners' discourses, routines and competences; and teachers' role in such classrooms.

The analysis of the study was therefore organised into themes and sub-themes which closely relate to the conceptual framework's Units of observation. The main themes and their sub-themes which framed the analysis were as follows:

- Pedagogical practices (the observed, implied and perceived):
    - Instructional Approaches,
    - Instructional discourses and routines,
    - Pedagogical communicative interactions;
- Learner-learner discourses and routines, and competences in Mensuration;
- Teachers' role in implementation of curriculum.

This chapter therefore presents the study's findings from the thematic viewpoint, as a way to show how the teachers and learners who participated contributed in responding to the study's critical research question.

10.1 Theme 1: Pedagogical Practices (The Observed, Implied and Perceived)

The nature of a classroom environment availed by each teacher was determined by looking into the type of instructional approach used (whether active or direct). These approaches therefore were used to determine the degree of learner-autonomy provided to learners. The type of instructional

environment created by each teacher was also described by the types of discourses (whether formal and mathematical or fully colloquial, and whether fully objectified or non-objectified) and routines (whether explorations or rituals) that exist between the teacher and the learners and amongst the learners themselves during the teacher's presentations and during learner discussions in each part of the lesson. Similarly, these were used to determine the level of autonomy learners were exposed to during each instructional proceeding. They were therefore analysed from the observed teacher-learner and learner-learner discussions during the teaching and during learner discussions as they worked on the given activities or problems involving taught or learned concepts of Mensuration.

Further, the way in which the teacher communicatively interacts with learners helped in describing the type of instructional or learning environment they were exposed to. Studying these interactions also helped in determining if such environment offered learners enough opportunities to be autonomous in their learning. The interactions were analysed from the teacher-learner conversations during the teaching process where explanations were required for elucidation of the concept under discussion. These three aspects of analysis therefore form the sub-themes which helped in organising the discussions around the findings which chiefly focused at what the teachers were found to be doing as they implement the curriculum.

10.1.1 Instructional Approaches

With regard to the instructional approaches used in the teaching of both Mensuration concepts, perimeter and area, the four teachers were found to predominantly use direct instructional approach. In their teaching of perimeter, each of the teachers displayed a large number of actions which identified their teachings as direct instructional approach. However, as would be expected, their teaching actions were not identical. For two of the teachers – Nthabi and Pita –,perimeter was introduced as a new concept to the class hence preceded by teacher definition of the concept, an authoritative review on properties of polygons, introduction of a formula or computational procedure, and providing a series of worked examples as demonstration of the shown procedure. Though in these instances there were teacher-learner probes, they were mostly authoritative and led to most unidirectional teacher talks. For instance, Nthabi introduced the computational procedure for perimeter of a rectangle through a probe to stimulate learners' thinking. The probe, however, became rhetorical in that whether learners answered correctly or incorrectly, the teacher

provided the formula and a worked-example. For each example, she would work step-by-step through it while leading learners with confirmatory questions to demonstrate how the new formula worked.

The other two teachers, Teko and Nkoe, began their lessons on perimeter in a totally different manner. Nkoe introduced the concept through a review probe on properties of shapes and idea of a 'site', which was soon followed by learners' out-side-classroom practical activity. This was therefore considered an active initiative by the teacher. However, in most instances throughout the introductory probe and practical activity, the teacher authoritatively guided learners to come up with correct answers and complete the task. This was soon followed by the teacher's change of focus on the formula for the perimeter of a rectangle which he demonstrated with worked examples. These follow-up actions by the teacher therefore turned his teaching into a more direct approach. Teko's teaching followed the same route since he began with a question-answer interaction to review properties of polygons, definition of perimeter, its computational procedure for different polygons and its units. Though these actions were considered to have actively engaged learners, the probing was more authoritative and the teacher mostly intervened by providing explanations and examples to show how the procedure worked on different polygons. These actions ultimately identified the two teachers' teaching as direct instruction as well.

In their teaching of the concept of Area, the four teachers were mostly similar in their instructional approaches. Each of them involved some probing that was followed by the teacher's explanations on definition and properties of some polygons. The teachers provided the learners with the formulae for the Area of specific polygons, followed by worked examples on the use of such formulae. For example, Nthabi began the lesson with an authoritative probe on the definition of Area, and properties of different polygons. She then took learners through formula introductions, explanations and worked-examples on Areas of different polygons, square, rectangle, and triangle. For all these teachers, the examples working was done by the teacher through explaining, writing workings on the board, and leading learners with some authoritative probe through the arithmetic process while calculating the area of such polygon. The teachers were therefore considered to have predominantly used direct instructional approach. This approach was further manifested when each of the teachers' worked-examples were followed by the learners' writing activity which

resembled each of the examples demonstrated by the teachers; this with the purpose of evaluating if learners had memorised and could accurately use the demonstrated procedures or formulae.

Even so, each of the four teachers displayed what could be identified as instructional actions which somehow belong to the active instructional approach, though these were minimal in each of their observed lessons. These actions included (but not limited to): giving learners an assignment on the concepts prior to the lesson; probing learners to define the new concepts, as part of the lesson introduction; giving learners some practical activity to perform on perimeter; probing learners to comment on the accuracy of each other's solutions for correction or approval; interactively probing them to seek their thinking/suggestions on computational procedure; inviting them to demonstrate calculations on the classroom board; using engaging-scaffolding to help learners make connections between real-life scenarios and concepts learned in class; and giving learners activity or problem-set to practise the taught formula or procedure. It could be concluded that each of the teachers predominantly relied on direct instructional approach in their teaching of the two concepts, Perimeter and Area. In most instances, even when learners were given the textbook activity or problem-set to actively practise the taught procedures/formulae or as a way to evaluate their understanding, the most observable role performed by the teachers was an authoritative probe to remind learners of the formula or over an arithmetic process, directly telling them the correct formula, procedure or arithmetic process to follow.

For each of the teachers, their direct instructional approach actions were further affirmed by their responses to the interview questions. For example, in concurrence with the observed actions, Nthabi mentioned demonstration of procedures and thorough explanations to direct learners to do the right things as her role in the teaching of Mensuration and during the learners' individual or group work on given activities or problems. Similarly, in addition to their concurrence with observed actions, Teko's responses provided some substantiation to his dominant use of direct instructional approach. He suggested – and was observed – allowing group discussions which promoted some interactions which could facilitate sharing of ideas between learners. However, in his responses, he cited some disadvantages of that learner-learner interaction including time consumption and needing much of the teacher's guide, hence thought it would be much better if the teacher just tells the learners everything while they attentively listen. He insisted that even

when they are given a task which they have to do independently, his role is still to persistently provide guidance for accurate completion of the task.

In some instances, the teachers' responses and suggestions included teaching activities which were not observed in their teaching or those which contradicted the observed teaching actions. These included: using games as part of teaching and learning; assigning pre-lesson research assignments; teachers acting as facilitators; and accommodating all learners' findings and redirecting their results towards correct conceptions. Most of these uttered activities were not observed during teaching, except the part where learners were given a chance to work on the given activity and the teacher's role as facilitative by going through learners' work and probing to direct them to correct procedures or answers. For example, Nkoe's utterances regarding instructional practices related to learner-autonomy included: allowing learners to handle materials and do research; grouping them according to their level of understanding; allowing them to proceed working on the new topics on their own; allowing them to do some working on the past examination question papers of their choice and submit to the teacher for evaluation, all which could not be observed since the study's observations were confined to active classroom teaching during lessons. It could therefore be concluded that the teachers partially correctly defined the concepts of active engagement and learner-autonomy while most of their observed actions, which were mostly direct instructional, contradicted these definitions and suggestions.

10.1.2 Instructional Discourses and Routines

Throughout their teaching, teachers mostly displayed colloquial discourses as they all tried to introduce each concept and drill learners to understand them. These discourses were mostly focused on explanations about processes learners had to follow to obtain correct answers (processual discourse) while using the procedures, and their talk was mostly personalised (personalised discourse), thus dominantly disobjectified discourses. For example, for Pita and Nthabi in particular, the teachers' presentations on the computational procedures and use of formulae for each concept was a way of leading learners to follow the procedures didactically. This was performed mostly without any attempt to make connections between concepts/sub-concepts while lacking activation of learners' logical substantiation for the use of such procedures. These practices therefore were indicative of each teachers' instructional routines as rituals.

However, in terms of the type and objectification of instructional discourses, Nkoe was slightly different from the other teachers. Since in most parts of his lessons the proceedings were dominated by teacher's unidirectional presentations which involved actions of direct instructional approach, the teacher-learner discourses were somewhat formal. These discourses were mostly about the definitions of the concepts of Perimeter and Area, their computational procedures or formulae, and the arithmetic processes that go with the use of the formulae in worked examples, and on problem-set. Due to the formal nature of his presentations, Nkoe's discourses were mostly objectified except in rare cases where he explained some procedures and formulae to correct learners' answers/workings as they worked in groups.

From the beginning of each lesson, teacher Nkoe's instructional routines mostly involved direct reminders on properties of some polygons in focus. These reminder sessions were executed as ways of getting learners started on the new concept of either Perimeter or Area.

However, similar to the other teachers, Nkoe's presentations were done without expression on the purpose or substantiations that could be related to the concept yet to be taught, hence qualifying his teaching as purely ritualised. This ritual nature of teaching routines was further observed throughout the lesson presentations, which involved: direct introduction of new concept by telling the definitions; providing and deriving the formulae while telling strict rules on what to use or what not to use (for example, half-length times width, instead of half-base times height); providing textbook worked examples to demonstrate rote use of the formulae; giving learners a problem-set to work on as a way to practise the rote use of formulae; and monitoring learners' progress by telling, explaining and demonstrating the correct way of doing the activity or arithmetic process.

All these were mostly geared at helping learners to memorise the new definitions, formulae and their rote use, without substantiation on selection of appropriate situations where each formula is most applicable or how they could be used connectively to solve real-life problems. This way, learners in each of the teachers' classes were exposed to a classroom environment which offered them limited autonomy or diversity in their acquisition of new knowledge.

10.1.3 Teacher-Learner Pedagogical Communicative Interactions

As part of addressing the purpose of the study, the type of instructional or learning environment that learners were exposed to was also characterised by the ways in which teachers interacted with them during concept-related explanations or discussions. Studying these interactions further helped in determining if such environment offered learners enough opportunities to be autonomous in their mathematics learning. More informative interactions surfaced from the teacher-learner conversations during the teaching process where explanations were required for clarification of the concept under discussion. These were therefore determined by exploring how often teachers involve learners in the pedagogical link-making narratives and the forms of communicative approach commonly used.

The teachers' displayed their teaching skills by involving some link-making explanations as a way of making the taught concepts clearer. They mostly used link-making to support knowledge building. For instance, throughout his teaching, teacher Nkoe produced a number of link-making explanations. These were:

- link-making to support knowledge building - making links between scientific explanations (concept of Perimeter, its scientific explanation and definition) and real-world phenomena (idea of length of a fence around the site);
- link-making to support knowledge building - making links between scientific explanations (concept of Perimeter and its definition) and real-world phenomena (the distance walked around the site or length of fence around the site);
- link-making to support knowledge building - making links between scientific explanations (definition of concept of Area) and real-world phenomena (the space enclosed by the fence of a site);
- link-making to support knowledge building - making links between scientific concepts (concept of Area as space enclosed by Perimeter, and concept of Perimeter as a boundary of Area);
- link-making to support knowledge building - making links between scientific concepts (Area and Perimeter of a rectangle); and
- teacher's link-making to support knowledge building - analogical link-making (dividing rectangular land into halves by diagonal, share a half for a Son).

However, it was only in one incident where learners were involved through a question-answer discussion. This was where the teacher led learners to introduce the concept of Area as a surface bounded by the Perimeter which the class had just calculated for a specific example. For all the four teachers, most of the link-making explanations were expertly executed by the teacher, while only involving learners through an authoritative probe in rare instances. The teacher communicative dominance was further displayed by their use of mostly interactive/authoritative and non-interactive/authoritative communicative approach while they rarely used interactive/dialogic communicative approach. This implied that most of the pedagogical talk was done by teachers, and when learners were involved, they did not have many opportunities to argumentatively take part by raising their opinions. It could therefore further be concluded that these learners were not availed classroom environments which could maximise their learning autonomy.

10.2 Theme 2: Learner-Learner Discourses and Routines, and Competences in Mensuration

In each of the four teachers' classes, learners were given some written activity and problem-set related to the taught concepts, Perimeter and Area, which came after the worked-examples. Learners were therefore given an opportunity to deliberate on these activities in trying to come up with the correct solutions. In particular, during the sessions on problem-set, the groups mostly repeatedly read the problem-scenario and brainstormed on the possible interpretations, hence tried to come up with computational procedures and solutions for the problems.

In each of the learner groups, the discourses were on the computational process (for instance, addition of decimals and two-digit numbers) with little focus on the concept to be learned (for example, Perimeter) hence colloquial discourse. Particularly for Nthabi, Pita and Nkoe, learners were mostly relying on the memorised formulae and struggled to use them, and even used them where they were not applicable, hence they were using predominantly ritual routines, probably instigated by their teacher's dominant ritual teaching routines.

On the latter issue, Teko's class was somehow an exception in the way they conducted their discourses. During the session on problem-set, the group members mostly read, repeatedly, the problem-scenario and brainstormed on the possible interpretations, hence tried to come up with the computational procedures for the problems. They did not show much reliance on the teacher's definitions, elaborations and given procedures, thus somehow their routines were explorations.

While on the problem-set activity (specifically on Area of polygon), the group managed to interpret the scenario and devised an accurate plan on solving the problem to find the correct answer. Their plan, which they managed to successfully execute, was to calculate the Area of a single triangle then multiply their answer by the total number of sides (12). Though the plan was correct and their routines were a bit explorative, the group committed a conceptual error in which they used the incorrect side of the triangle as its height. This indicated their incompetence in terms of the properties of polygons and computational accuracy.

However, in contradiction to their somehow explorative routines, and similar to other teachers' classes, Teko's learners in most instances had discourses over the computational processes (for instance, addition of decimals and two-digit numbers) with little focus on the concept to be learned, Perimeter, hence mostly colloquial discourse. Though learners' discourses were, in scarce instances, focused on the mathematical terminology, they were mainly on the addition process (processual discourse) and mostly personalised (personalised discourse). These discourses were therefore disobjectified hence indicated the learners' ritual routines.

In addition to disobjectified discourses, the ritual nature of learners' discourses was mostly visible in Pita's class. Instigated by their teacher's direct instructional approach, learners exhibited ritual routines including: passive listening and copying the teacher's examples; rote practices in using the given procedures while working on the exercises similar to the demonstrated examples; providing the teacher with answers and narrating used procedures without substantiation for their choices; failure to interpret and relate the problem scenario to the concept of Perimeter; and dependence on the teacher's examples and explanations to solve problems.

In addition to ritual routines, and especially in Pita and Teko's classes, learners showed lack of problem-solving skills and incompetence in understanding the concept of Perimeter (for example, their inability to relate the '*total length of the fence'* to the concept of Perimeter; and failure to identify the sides of the polygon to use in the formula for calculation of Perimeter). They could not identify the correct dimensions of the given polygon to substitute into the formula for perimeter, hence performed incorrect calculations even though they correctly used the formula and procedure, and the arithmetical process. Due to the direct nature of the teachers' scaffolds during group visits, every time after their intervention, learners were able to carry out the correct procedures using teachers' guidelines as they were. Despite that, all the calculations were performed with the aim of using the formulae learned but not to write up the solution which related to the way the problem was structured, hence the learners could still not be said to have mastered the problem-solving skills expected of them.

10.3 Theme 3: Teachers' Role in Curriculum Implementation

One of the main points of focus of the study was to determine how teachers understand their role in the implementation of the integrated curriculum which proposes Learner-Autonomous Environments (LAE). With regard to this, teachers mentioned a number of practices which they consider as their role. Each of the teachers considered themselves authoritative supervisors whose duties in a classroom include: moving around among learner groups to see how they are progressing with the given exercise; probing them to 'explain' their workings or procedures; and showing them where they are incorrect and guiding them towards the correct procedures; monitoring, supervising, marking for evaluation, and explaining explicitly where learners have difficulty.

For example, Nthabi further revealed that her major role throughout was providing the necessary explanations of concepts and computational procedures and assisting learners to understand by reading the questions and guiding them how to calculate. She further insisted that to improve the learners' competence, and promote autonomy, teachers should provide examples which involve things that learners are familiar with, including real-life objects, and they should concentrate more on teaching basic concepts such as arithmetic of basic operations.

This perspective indicates that these teachers preferred direct instructional approach and considered learners less capable of taking more responsibility in their learning. These articulated perspectives were also observed in each of the teachers' classroom teaching as discussed in Sections 10.1.1 and 10.1.2. Based on these implied and observed teacher perspectives, it could be concluded that these teachers had not yet observed the expectations of the new reform-oriented curriculum on them and hence were stuck in the traditionally oriented instructional practices and perceptions. Even so, the teachers' perspective understanding of the curricular expectations and their perspectives on the learners' competence somehow provided substantiation for their preferred instructional practices as their role.

For example, the teachers, especially Nkoe and Nthabi, expressed their perception that the curriculum is not well structured in terms of spirality of the syllabus and the mismatch between the difficulty of concepts and the learners' cognitive level. They insisted that the curricular content is much higher than the intellectual level of Grade 8 learners, and that the curricular expectations are simply not achievable. They therefore indicated that this low cognitive level of Grade 8 learners compels them to teach through direct instructional approach, as observed in their classrooms.

On the other hand, Teko described his role as a facilitator of all the classroom activities hence having to just lead learners to the correct concept development by availing the materials and making the content accessible without directly telling learners what to do or how to work through problems. This however, was contradictory to his and all the other teachers' observed instructional practices which were mostly based on direct instruction.

10.4 Conclusion – Classroom Environment and Opportunities for Learner Autonomy

In an attempt to address its research focus, the study revealed that teachers predominantly used actions which characterise their instructional practices as direct instructional approach. Though there existed some actions which could be considered to have actively engaged learners, these were limited and when they happened, the teachers still acted authoritatively. Therefore, viewed from the classroom observed actions, it could be concluded that those teachers led classroom environments which limited opportunities for learner-autonomy. These teacher-sided classroom environments were further verbally substantiated by the teachers who indicated that they were

forced to operate as they did due to the misalignment between learners' cognitive level and the difficulty level of the new syllabus.

The real nature of the classroom teaching allowed the teachers to practise mostly the colloquial disobjectified (processual and personalised) discourses which were geared at introducing and drilling learners to use formulae and computational procedures related to each of the two concepts, Perimeter and Area. Due to the direct instructional nature of their teaching, the teachers were found to be predominantly using ritual teaching routines as opposed to explorations. As would be expected of a mathematics teacher, the four teachers who participated in the study displayed their expertise by involving several incidents of link-making narratives throughout their lessons. However, in these incidents learners were rarely probed or given a chance to take part in producing such link-making narratives. The overall communicative interactions in each of these teachers involved dominantly teacher-sided talk, that is, they mostly used non-interactive/authoritative and interactive/authoritative communicative approaches. These approaches were therefore concluded to have limited learner contribution into the classroom dialogues which could have maximised their conceptual understanding.

In what could be called consequential learning practices, learners in these teachers' classrooms mainly displayed colloquial disobjectified discourses as they worked in their groups on the problems and activities given to them as a way of evaluating their understanding and allowing them to practise the given procedures and formulae. They also predominantly used ritual routines which were characterised by their reliance on teachers' prior explanations, examples and authoritative scaffolding, and they displayed some incompetence related to conceptual understanding and arithmetic accuracy.

The teachers' verbal descriptions of their roles in their classrooms somehow concurred and were substantial to their classroom observed practices which were mostly teacher-dominant. They described their roles as authoritative supervision, providing definitions and explanations, using more examples, and telling learners where they were going wrong. Based on the findings herein, the study concludes that the mathematics teachers were operating in a traditionally-oriented manner hence it was to be expected that the learners would show considerable incompetence in

terms of discourses and routines they used in their learning. In addition, their conceptual understanding and computational accuracies demonstrated deficiencies. The classroom practices and teachers' perceived roles therefore marked the classroom environments as lacking characteristics of a reform-oriented LAE hence learners had limited opportunities to learn autonomously.

Chapter 11: Interpretation and Conclusion

11.0 Introduction

The four chapters, Chapter 6, Chapter 7, Chapter 8 and Chapter 9, presented the data and its analysis as guided by the conceptual framework discussed in Chapter 3. Chapter 5, the Pilot study chapter, presented the piloting processes including the findings on the pilot data. The preceding chapter, Chapter 10, presented the thematic interpretation of the findings as presented in the four data-focused chapters. The presented analysis in these chapters, therefore, forms the major findings of the study. In this chapter, the findings are integrated from each of the five preceding chapters to describe the nature of the instructional environments observed from each observed class. By interpreting these findings, I therefore present how the study addresses its main research question*:* ***What is the nature of Grade 8 classroom environments created by mathematics teachers as they work towards implementation of the integrated curriculum, which calls for LAE (focusing on Mensuration)?***

To show how the main research question is addressed, I begin the discussion by highlighting how each sub-research question is addressed in terms of the aspects of the conceptual framework as presented in Chapter 3. The sub-research questions are:

- *What types of instructional approaches (active vs direct) do teachers use in Grade 8 classrooms?*
- *What types of discourses and routines exist in these environments, when teaching or learning Mensuration?*
- *How do these types of classroom discourses and routines relate to how learners understand Mensuration concepts (learners' competences)?*
- *How do teachers and learners interact during the teaching-learning of Mensuration concepts (Perimeter and Area)?*
- *How do the Grade 8 mathematics teachers understand their role on implementation of LAE-oriented curriculum in teaching Mensuration?*

The interpretation and discussion of the findings under each of these sub-questions ultimately lead to the description of the instructional environment in each of the classrooms in terms of the types

of instructional approaches, discourses and routines, learner competences, and the interactions of the teacher and learners, hence associating these constructs to the concept of learner-autonomy as a way of addressing the main research question. The final sections of this chapter present the recommendations ensuing from the study, and the limitations of the study bring it to its conclusion.

11.1 Overview of the present Study

This study was aimed at exploring the nature of classroom instructional environments created by selected mathematics teachers as they implement the integrated curriculum, which proposed LAE, as they teach Mensuration concepts. From the rationale and problem statement presented in Chapter 1, I highlighted the school experience I had with the learners and their teachers during the first phases of the implementation of the integrated curriculum. This was in relation to the learners' observable chaotic behaviour as they were taught mathematics in their classrooms, and the teachers' description of such learner behaviour as being 'active' and therefore giving them such freedom as 'mandated by the curriculum'. I also highlighted the dissatisfactory performance of learners in Mensuration-related final examination questions which I experienced in my duties as a marker and a classroom teacher for several years. I therefore ventured to look closely into the classroom teaching and learning environment as teachers taught the concepts of Mensuration in trying to implement the 'mandated' curricular expectations (presented in Chapter 1).

As an explorative interpretivist research, this study therefore attempted to answer its main research question by focusing on instructional approaches (observed and uttered by teachers), discourses and routines (teacher-learner, learner-learner), learners' observable competences, and teacher-learner interactions (communicative). These aspects formed the sub-research questions of the study. In line with these points of focus, I integrated concepts from the reviewed literature (Chapter 2), curricular expectations (Chapter 1), and from two theories, Commognition (Sfard, 2008) and Pedagogical link-making, and Communicative Approach (Scott *et al*., 2011; Mortimer & Scott, 2003), to form a conceptual framework (Chapter 3) on which the analysis of data relied.

The utilised data collection and processing methods were presented in Chapter 4. The highlighted methods include classroom observations (whole-class and selected-group observations), and teachers' interviews. The study therefore generated three sets of data: video-taped whole-class

observations, selected-learners group discussions, and teachers' interviews data. The Pilot study research processes and developmental changes made for the main study were presented in Chapter 5. The discussion in that chapter include the review on what was proposed as the study began and the changes to the instruments, research questions, and analytical tools of the main study as a result of the Pilot study.

All the data sets from the four teachers' classes were presented and analysed as cases in four chapters: Chapter 6 (Nthabi's class); Chapter 7 (Teko's class); Chapter 8 (Nkoe's class); and Chapter 9 (Pita's class). In each of the four chapters, I narrate the actions and communication of the proceedings of each lesson as it happened. I then substantiate each part of the story with an extract from the raw data, followed by analysis of that part of the story. The analysis in each of these sections of data presentation focuses on: instructional approaches; discourses and routines; learners' observable competences; and teacher-learner interactions. Each of the data and analysis chapters is concluded by highlighting the main findings and the ensuing relation of such findings to the concept of LAE as the central focus of the study. These findings are further discussed under three main themes in Chapter 10 where the four teachers' pedagogical practices, their roles and their learners' practices are compared and contrasted against each other and in relation to the study's conceptual framework.

11.2 Addressing the Study's Sub-Research-Questions

To address the main research question of this study, I ventured to address the five sub-research questions as presented in the next sub-sections. The respective research questions are presented in the subsequent sections where the findings that resulted from each of the analysis chapters are discussed. The discussion in each sub-section shows details of what was found and how that answers the research question and how these relate to the relevant literature reviewed in Chapter 2.

11.2.1 Sub-Research question 1: *What types of instructional approaches (active vs direct) do teachers use in Grade 8 classrooms?*

In order to address this research question, each teacher was observed and later interviewed with the aim of exploring their instructional approach preferences; whether what they do as part of

teaching proves to be of active instructional approach or direct instructional approach. As discussed in Chapter 2, the direct instruction-oriented teaching scenario is signified by teaching strategies which focus on development of definitions of concepts, learners' rote use of formulae and their procedural fluency which entails knowledge of procedures, knowledge of how to use them appropriately, and skill in performing them accurately, and efficiently (Phuong, 2020). In contrast, an active instructional approach-oriented teaching-learning scenario is characterised by a classroom environment that involves teaching-learning strategies which actuate learner-learner and non-authoritative learner-teacher interactions (Petersen & Gorman, 2014), and allows learners to engage in mathematics tasks requiring their deeper cognitive engagement where they construct meanings and conceptual understandings and make connections of the subject matter (Bjørkestø *et al*, 2021).

Regarding the types of instructional approaches used by teachers, the findings of the study revealed that each teacher predominantly used a direct instructional approach. Conversely, each teacher's use of an active instructional approach was minimal. Each of the four observed teachers (Nthabi, Teko, Nkoe, and Pita) mostly displayed actions which were interpreted as contribution to their direct instructional approach in the teaching of each of the Mensuration concepts, Perimeter and Area.

Though their lesson proceedings could not be said to be similar in the teaching of the two Mensuration concepts, the teachers introduced them as new concepts to their classes. However, Teko was an exception since he treated them as revision sessions on definitions, formulae, computational procedures and units. In both ways of their introduction, teachers' practices mainly involved direct instructional approach actions such as: providing definitions of the concepts; providing worked examples to demonstrate the computational procedures or how the formulae could be used; derivation process of the formula; explanations on how to identify or come up with the units of their final answers; and providing alternative computational procedures for calculation of each concept for different 2D shapes. These actions, including others which are reported in previous chapters, could be said to have not allowed learners to contribute much to their learning since they were mostly passive recipients of the concepts as teachers presented to them.

Even so, these teachers' practices were not without some actions which could be said to have engaged learners actively, even though these were minimal. For three teachers, Nthabi, Teko and Pita, this was evident where they involved learners in question-answer discussions to activate their prior knowledge or demand their thinking or suggestions on the definitions, computational procedures, formulae, units, or properties of the 2D polygons. Learners could be considered to have been actively engaged since they had to respond to teachers' questions accordingly. Contrary to the other teachers, Nkoe began the lesson on Perimeter by exposing learners to a practical session outside of the classroom where they were to practically measure the perimeter of rectangular shapes then compare to addition of measured sides of such shapes. For each of the teachers, learners were further engaged actively through textbook activities and a problem-set to work on, as a way to give them the chance to practise and perfect the taught procedures and formulae they had just been shown.

It could however be concluded that learners were mostly superficially engaged since in most of these actions they were responding to their teachers' authoritative probes and scaffolding. For instance, in Nkoe's case, learners were to measure the whole perimeter of their rectangles and compare with addition of sides however, the purpose of the exercise was not clearly explained hence was not understood by the learners. The teacher then authoritatively guided them to complete it. He further abandoned the practical exercise and told learners the formula to use to calculate the perimeter and demonstrated with a series of examples.

Furthermore, in all the learner activities, the teachers' interaction with the learners was more authoritative and meant to strictly direct them to conform to the given formulae and procedure. The observed role played by each teacher in learners' group work was to provide explanations with correct answers to show the learners that their workings were incorrect. This indicated that these instructional practices were performed to ensure that learners followed and replicated what was explained and demonstrated to them, without provision of substantiation or deviation from the rote procedures.

These findings show – though in a few incidents per observed lesson – that each of the four teachers' instructional practice involved some actions of active instructional approach. As

described by Sochima (2022), exposing learners to these teaching-learning scenarios improved their interest and opportunities in actively taking part in their learning and improved their conceptual understanding in Mensuration, better than when it is taught through expository and direct instructional approach. In concurrence with Richit *et al.* (2021) Nkoe's outside-of-classroom practical activity, where learners used measuring to actively and exploratively learn the concept of Perimeter, was to allow them to construct and expand their understanding of Perimeter as a measure requiring knowledge of using measuring tools.

At different parts of their lessons, the four teachers' practice involved a series of questions which were followed by learners' responses accordingly. The questions demanded learners' prior knowledge or ideas for definitions and computational procedures for the concepts: Perimeter and Area, properties of polygons, and questions meant to evaluate learners' comprehension of demonstrated procedures, including problem-set questions. These are sets of questions that Chirayangyuenyong, Emarat and Arayathanitkul (2023) referred to as 'concept-guiding questions, comprehension-checking questions, and concept-applying questions', whose central focus was (and were found) to arouse learners' courage to learn, enhance and challenge their understanding of the concepts.

All the same, as presented in the above preview, each of the four teachers predominantly used a direct instructional approach which was driven by teacher-dominated activities. As Phuong (2020), and Petersen and Gorman (2014) expressed it, these teaching actions fostered didactic transmission of information from teachers to learners hence ultimately focusing on the development of learners' procedural fluency (and rote use of formulae) instead of development of their deeper conceptual understanding. Similar to the study by Vale and Barbosa (2020), among many other teaching actions, the four teachers were found to be providing learners with explanations for each new concept, providing formulae and worked examples to demonstrate the computational procedures (or use of formulae) for Perimeter and Area of different 2D shapes. In most incidents, the examples were followed by a similar-characteristic exercise given to the learners to perform the demonstrated procedures as a way to practise and apply the knowledge just acquired.

11.2.2 Sub-Research question 2: *What types of discourses and routines exist in these environments, when teaching or learning Mensuration?*

Discourses in a mathematics classroom are construed to improve learners' mathematical reasoning and conceptual understanding through intentional, focused and shared social interactions to enable learners to reason out, confirm and challenge their mathematical ideas (Bennett, 2019). The types of discourses and routines executed by the teacher during the mathematics teaching can therefore determine the degree of learner-autonomy made possible for the learners.

Regarding the types of discourses and routines displayed during the teaching-learning processes, the study's findings revealed that each teacher predominantly used disobjectified discourses and ritual routines. The findings also revealed that the learners in each of these teachers' lessons were mostly involved in ritual routines. In most of their teaching talks, teachers were found to be involving their classes in colloquial discourses which were focused on providing explanations on specific concept-related aspects such as definitions, formulae, computational procedure and how they apply in different examples.

However, with teachers Nkoe and Teko, due to their practices which were deeply rooted in direct instructional approach compared to the other two, their discourses with learners involved direct and structured explanations accompanied by a series of examples. This therefore guaranteed their discourses to be more formal while livened up with some colloquial discourses in some rare instances. For instance, in Teko's class, he led discourses which were mostly focused on reminding learners of the two concepts (Perimeter and Area) and the computational procedures or formulae used for different types of shapes. These discourses therefore were mostly formal (during teacher's presentation) while enlivened with colloquial discourses where the teacher tried to use examples from learners' real-life situations to elucidate his elaborations and provide extra hints to enable learners to provide responses accordingly.

In contrast to the other three teachers, due to the formal nature of his teaching presentations, Nkoe's discourses were mostly objectified (impersonalised and structured) except in rare cases where he explained some procedures and formulae to correct learners' answers or workings as they worked in groups. The other teachers, instead, mostly used disobjectified (personalised and processual)

discourses. For example, in Pita's teaching, the teacher-learner talk was mostly personalised and lacked structure and conceptual understanding focus for learners. In instances where a probe was used, most of the teacher's questions included personalised terms such as '*you, we, our*' and they were about the processes followed by the learners, hence they had to respond in a personalised manner and were mostly concerned with the processes followed. For example, the teacher's discourse on the production of halve triangles was personalised, and obtaining such result emanated from their performed processes (*use of we, or you: 'how do you find area of a square or area of a rectangle?'*), thus the discourse was disobjectified.

As Sfard (2008) indicated (discussed in Chapter 3), the disobjectified nature of the teaching routines imply that the teaching routines were mostly rituals. In addition to the disobjectified discourses, teachers were further found to be practising in teaching actions which were classified as teaching rituals. For example, in Pita and Nthabi's classes, teachers tried to address learners' reported lack of understanding by a direct repetition of all the explanations, demonstrations and steps followed in the prior presentations. These actions proceeded, in most cases, with no explorative probe towards learners on the particular parts of the presentation where they got 'lost'. They also lacked logical substantiation relating the explanations and the operations on the shapes. These aspects therefore qualified the teacher's routines as rituals since their focus was a repeat-and-perfect presentation which was separate from the concept of Area in discussion.

Further, though the two teachers, Nkoe and Teko, displayed objectified discourses, just like the other teachers, most of the activities were solely executed to allow learners to memorise the given procedures. In some instances, the discussions were focused on the addition process which appeared to exist separate from the concept of Perimeter learners were being taught. The teaching routines, for example, were characterised by providing explanations, giving worked examples, drilling learners to memorise and be perfect in the use of formula, lack of substantiations for the procedures and their choices. Most of the lesson routines were geared to allow learners to memorise the computational procedures and practise with them on several similar exercises, without much focus on the learners' deeper understanding of a concept.

For example, Pita's presentation on the transition from the use of 'Length and Width' to 'height and base' as critical attributes of the formula for the area of a triangle was presented as a direct unidirectional presentation from the teacher. Though it followed immediately after the direct demonstration of derivation of $A = \frac{1}{2}(L \times W)$, the transition to the new formula $A = \frac{1}{2}(b \times h)$ was not made explicit and was never explained in relation to the concept (or its definition) of area. The further presentation on the area of a right-angled triangle and how to identify the height and base was a further step to acquaint the learners with the new formula.

As a result of teachers' ritual routines, learners' routines naturally followed. Learners' ritual practice was almost unavoidable since in each of the observed classes most of the routines were focused at leading them to memorise the new definitions, formulae and their rote use, without clear substantiation on their necessity or alternatives and selection of appropriate situations where each formula is most applicable or how the formulae could be used connectively to solve real-life problems. The learners therefore, were mostly relying on the memorised formulae and struggled to use them even where they were not applicable, hence they [learners] were using predominantly ritual routines, instigated by their teacher's dominant ritual teaching routines. Similarly, learners' discourses involved mostly processual and personalised talk over the lesson content, probably as an instigation by their teachers' disobjectified discourse.

These findings reveal that the four teachers mainly used rituals as the routines which characterise their instructional practices. Ritual performance is characterised by lack of narratives construction and substantiation, and focusing solely on how something is procedurally done. Therefore, for this kind of routine to be performed, the figure in authority (the teacher for example) needs to state all the steps to be followed and performers thus follow strictly these stated steps to reproduce the routine (Mahlaba & Mudaly, 2022), thus following didactic methods of knowledge development as observed in this study. In addition, ritual performance is considered to focus on manipulation of mathematical symbols (for instance, algebraic formulae for Area of triangle), without any reference to the objects signified by them (for example, the concept of Area), and it also includes mentioning the actions carried out by humans on mathematical symbols (Heyd-Metzuyanim, Tabach & Nachlieli 2016).

In line with these descriptions of ritual performance, the observed teachers introduced the concepts Perimeter and Area through direct telling and explanations of definitions, formulae and providing examples to demonstrate how the formula is used step by step. In most cases, this sequence of routines was followed by giving learners an exercise in which they were expected to perform the use of such formulae or procedures as demonstrated by the teacher. For example, in teacher Pita's class, he presented the process of deriving the formula for the Area of a triangle from the formula for the Area of a rectangle. He then provided the class with an example to demonstrate how the formula is used to calculate the Area of any right-angled-triangle.

In addition to this sequence, teacher Pita tried to correct and guide learners to write accurate workings by directly telling and showing them what to do and did not probe them to substantiate their workings or provide reasoning for their lack of understanding. These findings concur with those by Heyd-Metzuyanim *et al.* (2016) where one observed teacher displayed actions of ritual participation by not insisting on engaging a learner in mathematical reasoning. In that study, when a learner in focus made mistakes and showed lack of understanding in their mathematics workings, the teacher was reported to have not demanded justifications, and gradually constrained the possible answers in a way that did not provide the learner an opportunity to express abstract mathematical ideas in their own words.

The findings herein also suggest that teachers dominantly engaged in instructional discourses which were focused on processes performed by the learners (or teacher with learners). These discourses therefore were concluded to be disobjectified since they were mostly processual and personalised. Thus, the findings of the study reveal that teachers did not create discourse environments which could develop learners' mathematical talk. This was further confirmed by the realisation that learners' discourses were generally disobjectified as they worked on the given exercises and problem-set activities. In most instances, learners in each of the observed teachers' classrooms engaged in discourses which focused on the processes of adding the sides of a polygon (for Perimeter), identifying dimensions of polygon to use, substituting such dimensions into the given formula and carrying out the arithmetic processes to find the answers. These were communicated as performances of such learners as a group, hence their talk was processual and personalised.

For example, in teacher Teko's class, groupmates in Tumo's group struggled to identify a line in a triangle to substitute as height in the given formula for Area of triangle. This was the first step in calculating the total Area of a 12-sided regular polygon to which the triangle was part. Due to the processual and personalised discourses executed by the teacher during his presentation on the derivation and use of such a formula, the group's discourse focused on the process of identifying the height of the triangle, using it to calculate the Area of the triangle, then multiplying the result by 12 to get the total Area of the 12-sided polygon. Their discourse therefore, was fully processual and personalised, hence non-objectified. This result however is somehow in contrast with a couple of studies on teachers' objectification of discourses in mathematics teaching. In studies such as Güçler (2013) and Güçler (2014), the teacher's discourse on the concept of limits was found to be dominantly objectified, while learners' discourses showed no objectification of the concept.

In those studies, teachers displayed discourses focused on the structure of the concept while showing difference to the processes involved in it, but the learners' discourses focused on the operations carried out by the learners themselves in dealing with the concept-related problems. Additionally, and slightly deviating from this result, Johansson and Österholm (2019) found that though teacher's discourses are mostly objectified, and difficult for most learners to get to that level of objectification, the same learners seem to acquire a certain degree of objectification when more familiar symbols or concepts are used in their talk. This somehow concurs with the findings in the present study, where a group of learners (Tumo's group) were able to produce objectified (hence a bit of explorations) discourse when they were allowed to communicate in their home language, Sesotho, and on familiar polygons.

While the latter deviation of my findings from some reviewed literature exists, the study argues that the teachers' persistent processual and personalised discourses as they executed the teaching of the concepts, Perimeter and Area, gave rise to the learners' disobjectified discourses which were part of indications of ritual performance in their learning. This also indicated that the teaching routines, instilled by disobjectified discourse, were not close to enabling the de-ritualization (Lavie *et al.,* 2019; Sfard 2008) of learners' routines.

11.2.3 Sub-Research question 3: *How do these types of classroom discourses and routines relate to how learners understand Mensuration concepts (learners' competences)?*

The teaching and learning of Mensuration concepts, Perimeter and Area, involves explanations, discussions, use or derivations of definitions, formulae, units, computational procedures and may involve problems for which the solutions need thorough understanding of these, and the concept as a whole. Therefore, learners' ability to solve the problems which involve these aspects may reflect their conceptual understanding which is brought by their exposure to the type of learning environment they are exposed to. This was analysed from the learners' talk (discourses) and actions (routines) as they worked on given activities and problems. The outcome of this analysis therefore determined the learners' competence in problem-solving and manipulative skills, understanding of the concepts, and engagement in objectified or disobjectified discourses and exploration or ritual routines.

The analysis, which was focused on the learners' discussions (from each teacher's class), on given problems suggested learners' varied competence levels in terms of: problem-solving skills; manipulative skills; understanding of the two concepts, Area and Perimeter; use of objectified mathematical discourses or disobjectified discourses; and their use of routines (rituals or explorations). However, all the learner groups from each teacher's class showed lack of understanding of the concepts of Perimeter and Area, and their discourses were mostly disobjectified (except in rare cases, such as in Teacher Nkoe's class) adding to their dominant use of ritual routines.

Particularly in teacher Nthabi's class, while working on the given problem-set, learners were probed by the teacher to narrate the procedure they had followed to obtain the answer for the Perimeter of the given polygon. The teacher talked to them in a more processual manner hence their talk indicated that this routine was a ritual with their answers lacking reasoning and substantiation of why the calculations were correct that way. Learners showed no intention of elaborative argumentation on the workings they provided, probably because the teacher's questions did not demand them to. This result resonates with Heyd-Metzuyanim and Graven (2016) who postulated that every ritual-oriented participation of learners could be aligned with a ritual form of instruction executed by the observed teacher. To substantiate this, in their study,

Heyd-Metzuyanim and Graven found that the instruction led by one of the observed teachers, *'Mrs. X'*, was purely ritual-oriented hence the routines of the learner under study, '*Mina',* were focused at pleasing the teacher and following her rules as they were, hence purely ritualised.

Nthabi's learners showed some difficulties when dealing with the problem-set and the somewhat hesitant talk among them indicated (to their teacher) this difficulty to interpret the problem-scenario and the subsequent questions, hence their failure to connect the scenario to the concept of Perimeter. The teacher's scaffolding involved leading questions, to help the learners identify the concept implied by the question. In their conversation with the teacher, the learners responded by showing parts of the scenario they understood and identified sizes of the sides as pointed and directed by the teacher. They however seemed to just follow the teacher's guide to arrive at her most desired response in answering the given question under the problem, without indication of deeper understanding of the concept or related question, hence no substantiation provided. The learners' routine at this stage, therefore, were identified as complete rituals since –,as Heyd-Metzuyanim & Graven (2016), and Essack (2015) identified – learners' actions were only geared towards pleasing the teacher by following exactly what they were directed to do or say.

In some rare instances, in both teachers Nthabi and Teko's classes, though their discourse was not fully objectified and routines not entirely de-ritualised, learners could be argued to have been able to express their understanding and interpretation – of the given scenario and subsequent questions –,when they discussed mostly in their home language (Sesotho) while including a few English words and those related to Perimeter and Area. The latter observation concurs with teacher Nthabi's perspective which was reflected during the interview session, where she described the home language as one antecedent of what could signify learners' autonomy in their mathematics learning. Since the two Mensuration concepts, Perimeter and Area, were newly introduced to them and most of the teaching was done in the English language, learners could be said to have found refuge in using their own language, hence they had anchored their knowledge development of new concepts as applied to familiar situations (Makonye, 2019). In doing so, learners engaged translanguaging as they escaped the linguistic confinement of usual classroom teaching and learning to negotiate their mathematics learning (Makalela 2015; Makonye, 2019). As Makonye

puts it, the conceptualisation of the concept under discussion became accessible since learners were able to refer to familiar objects and situations as they deliberated on the problem-scenario.

When dealing with the concept of Area, the learners in Nthabi's class demonstrated their ability to recall the formula for the Area of a triangle. Learners interpreted the question as requiring that they calculate the area of one triangle in the polygon, followed by multiplying the result by the number of congruent triangles. However, the group showed that even though they had the formula in their memories, they had not understood how it came to be and why it was applicable for Area of a triangle. This was observed in their difficulty to identify the sides of the triangle to substitute as its base and height. Though they finally agreed on the correct multiplication process of 2-digit numbers, and they arrived at the correct answer, the group had difficulty with this operation hence they committed a few computational errors before they could arrive at the correct answer, thus showing some level of incompetence in terms of concept understanding and arithmetic manipulations. These learners also showed a weak level of problem-solving skills. Their discussion on the Area concept was purely on the use of the formula (substitution of the height and base) and the arithmetic processes (multiplication and addition). There was no reference to the problem or its solution (*Area of the yard occupied by all animals*), which would have been the reason for performing the calculations. Furthermore, their discussion and computations had little to no indication of any manipulative skills and critical thinking (that is, dependence on memory of formula and multiplication process).

To some extent, the above result echoes the study on the use of translanguaging by Makonye (2019) in which before the intervention, learners were found to be confined to the rote use of formulae for Perimeter and Area without any display of deeper conceptual understanding of the two concepts. One outstanding observation in that study was that learners showed a huge lack of understanding of the concepts since they even confused one concept for the other when given an activity to work on (inaccurate use of one formula in place of the other).

The learners' rote memorisation and use of formulae without understanding of the related concepts, observed in Nthabi's class, concurs with findings by Machaba (2016), where learners showed lack of conceptual understanding by defining the concept of Area as the formula, length

times width, and their activities were mostly focused on using the formulae while identifying the sides to substitute as length and width. Concurrently – and additionally in the present study – teacher Nkoe's learners, Ts'epo and Mary, shortly read the problem-scenario together and immediately started brainstorming on which sides of the polygon were length and width, hence relating them to the formula for Perimeter (of a rectangle). The group's decision of calculating the Perimeter to answer the question on the problem-set (which did not specifically state 'Perimeter'), could be related to the teacher's information prior to the exercise that they had to calculate the Perimeter in that problem. The learners could not be considered to have confidently interpreted the scenario and related it accurately to the taught concept of Perimeter, hence indication of some incompetency resulting from the non-conceptual teaching they received.

Though they already were told that they have to calculate Perimeter, it became hard for the group to locate the dimensions (or their magnitudes) of the polygon to use in calculating such Perimeter. This was observable when Ts'epo tried to measure the lengths of the unlabelled sides of the shape in the polygon. This act of measuring could be interpreted as indication of learners' understanding of the concept of *Perimeter as a measure* (Richit, Tomkelski & Richit, 2021), which could have been instilled by the teacher's introductory practical session, where learners measured the sides of their 'sites'. However, the question under discussion demanded them to identify the sizes of unlabelled sides of the five-sided polygon, then use them to calculate the Perimeter of the polygon. The measuring was therefore not required since the figure was not to scale and the learners had to rely on and use their understanding or prior knowledge of properties of regular and irregular polygons. This indicated the learners' incompetence and lack of problem-solving skills in terms of understanding the properties of regular and irregular polygons.

The group was further held up at the use of the length and width, and the related formula (taught) for the Perimeter of a rectangle (Perimeter = 2L + 2W). This was observed when they laboured to brainstorm on which lines on the diagram the length and the width were, and, at times, the height and the base. Their discussed formula, or its related length and width, was inappropriate for the current given polygon and for the given problem. This showed their lack of understanding of the concept of Perimeter, and indicated their dependence on demonstrated formula which they never

understood where and when (appropriate examples) it was most applicable, or where it could not be applied (non-example). This dependence thus indicated their ritual performance.

Eventually the group used the incorrect idea of length and width, but they correctly identified all the lines on the polygon which made up its Perimeter. Coincidentally, the group used the formula and they obtained the correct answer. To get to this, they changed the formula into Perimeter = 2L + 3W to accommodate the characteristic property of the given polygon (2 sides equal and 3 others equal on their own), hence correctly substituted the sides into their adjusted formula. This therefore got them the accurate answer, which they could have obtained if they had applied the correct computational procedure.

The incorrect and persistent use of the formula (Perimeter = 2L + 2w, for rectangle) and adjusting it to fit the current irregular polygon (which was not a rectangle) was an indication of the learners' inability to deviate from the use of the taught formula yet they could not identify where the formula was appropriate. This was also a display of their performance of the computation and rote use of formula (as demonstrated by the teacher) without deeper understanding and any connection to the concept of Perimeter or its definition, hence a ritual routine. This dependence on the formula is what Machaba (2016) called learners' overgeneralisation. Similarly, in his study, Machaba (2016) found that after working of the Area of a rectangle, learners persisted on using the formula, $A = l \times b$, even when working on the Area of non-rectangles, hence indicating lack of understanding of the concept and properties of different shapes.

Just like in the classes of the other two teachers (Teko and Nkoe), Nthabi's learners also had a discussion on a problem which demanded interpretation of problem-scenario, connecting it to the concept of Area, and calculation of the Area of the 12-sided regular polygon. The group failed to interpret the scenario and struggled to come up with the computational procedure. In their struggle, they failed to identify the sides of the polygon representing 'length and width'. This indicated that they wanted to use the formula for the Area of a rectangle as demonstrated by the teacher previously. When they failed to identify the length and width of the polygon, the group complained that the teacher did not give them an example, hence they visited their textbook to look for examples which they did not find helpful. This was a further indication of their lack of problem-

solving skills and understanding of the concept of Area, and reliance on teacher's example-demonstrations to which they would conform, hence their ritual routine performance.

These results show that in each of the four teachers' classes, learners had difficulty solving the problem due to lack of understanding of each concept and lack of problem-solving skills related to the concepts of Perimeter and Area. In line with these findings, a study by Abadi and Amir (2022) revealed that learners of various ability levels show difficulty and lack of problem-solving skills when working on Perimeter and Area, especially on combined plane (2D) figures. Similarly, in the present study findings, these difficulties include using appropriate formula per concept (Area or Perimeter), inaccuracies in arithmetic processes, units and dimensions of the plane figures.

Further, in Nthabi's class, though their routines were rituals, learners talked of the formula for Perimeter of a rectangle as a structure to use for obtaining the correct value for Perimeter of the polygon, hence their structured discourse. Their talk over the use of their formula and the arithmetic operations thereof, showed that they considered the formula and the arithmetic operations existent on their own as opposed to considering them as personally performed for existence. Though it seemed coincidental, the learners' discourses in this part of the lesson could thus be considered, to some extent, structured and impersonalised hence somehow objectified.

When working on the Area of a polygon, learners' difficulty to identify (and reach agreement on) which sides (13m, 12m or 5m) were to be used as the base and height of the triangle indicated their reliance on ritual routines, in which case they only memorised the formula and the computational procedure. Each of the discussants made their suggestions by trial and error without actually giving reasoning (from known properties of the shape or any information from the problem scenario) as the basis for their choice. Though Seratsi (one of the learners featured in this study) showed some expertise in the choice of the correct dimensions and sequence of operations (which operation follows after which), she did not provide the group with any substantiation for her choices. Throughout their discussion, Seratsi seemed to possess all the powers of the group while the other groupmates had to just operate as she did and suggested to be considered correct. This result was identified by Heyd-Metzuyanim and Graven (2016) with *Mina* who depended on those that she considered as authority, the teacher or other authoritative learners and their writings, hence her

routines were considered rituals. This ritual nature of learners' routines was further affirmed by the disobjectified nature of their discourses. They talked of the Area to be obtained as a process of multiplying base by height by half and adding the Areas to obtain the total Area, hence the discourse was processual. They also mostly talked of their activities as the entity of their doing (use of: *we, I, re…*) hence personalised discourse.

In line with this result, Johansson and Österholm (2019) highlighted a number of findings from several studies on the concept of objectification as a way of advancing mathematics knowledge. In their study, they observed that whether the teacher's discourse shows some degree of objectification, most learners fail to objectify in their discourses on various concepts, with their discourses mostly process-oriented and personalised. Thus the concept of objectification of discourse remains a complex issue on the side of learners, especially if the teacher's discourse shows very limited objectification during instruction. This concern over the difference or similarity of teacher versus learners' discourses in terms of disparity of objectification was further advanced by Sfard (2016), where mostly, learners' way of talking about mathematical objects is influenced by the way their teacher uses words. This is to say, there exists a higher possibility for learners' talk to be process-oriented and more personalised if the teacher's instructional talk consists of processual and personalised talk over these objects.

In a similar contention, in terms of learners' competence on the subject matter (conceptual understanding and problem-solving skills), the use of ritual routines over explorations, and their objectification of discourses, Teko's learners – to some extent – displayed similar characteristics to the learners in Nthabi and Nkoe's classes. In their discussion on how to answer the question demanding calculation of Area of the whole 12-sided polygon, the group tried to use some explorative routines by making suggestions on how to find the total Area. Here they agreed to multiply their answer to the Area of one triangle by the total number of sides of the polygon.

In addition, Tumo suggested that the operation be addition of those Areas though there were no 12 calculated Areas in their writings. However, Tumo had very limited reasoning power to be considered explorative in his talk. If only the operational suggestions relied on the jargon used in the problem in addition to the memory of different types of polygons and number of sides of the

polygon provided in the question, their routines would be considered explorations. The ritual nature of the group's routines was evidenced by the unconscious use of the formula (for Area of triangle) without understanding the concept of Area and the properties of the shape (triangle). The learners' dependence on the teacher's explanation and scaffolding analogy proved to be their target as their work relied on what their teacher had told them to do. This ritual of working towards pleasing the teacher by doing as told was further attested by the processual, non-structured and personalised talk (hence non-objectified) about the procedure to follow.

Though their routines were mostly rituals, the learners did try to use explorative routines (elaboration as they read and interpreted the scenario) and tried to use addition as an alternative to multiplying. Much of their persistence was fuelled by the teacher's probe which made them aware of the dimension to use as height. The learners' failure to make reference to the stated problem and discussing their calculations as a solution to the given problem showed that they lacked problem-solving as a skill required in learning Mensuration.

This group committed a conceptual error by correctly using 12 as a height for a single triangle and while they then multiplied by 2 with their understanding (or lack thereof) that it would represent the whole 12-sided polygon. This further indicated their incompetence and the ritual nature of their routines since they only mastered the use of the formula (for Area of triangle) while they lacked understanding of when to apply such formula. Also, their discussion in the choice of 24 as a height was not substantiated. This was further evidenced by their dependence on the teachers' explanation (since the only reason they provided was re-mentioning what the teacher had said) and on the processual and personalised (hence non-objectified) nature of their discourse on the calculation of the height and the Area of the triangle in their discussion.

Even so, for this class, it could be argued that the learners' patterns of engagement could not be divorced from their teacher's authoritative yet interactive scaffolding during the group visits, especially when the group showed difficulty in interpreting and hence performing accurate computations. The learners therefore could be argued to have been relying on ritualised learning routines in which case the exploration and elaboration of the concept of Area was not their priority but retrieval of previously memorised formulae and computational arithmetic processes. The

learners' inconsistent persistence to interrogate each other's decisions in the choice of the correct dimensions for height and final calculations for the total Area could be argued to stem from the knowledge that the teacher would provide the guided scaffold. The three groupmates (Tumo, Mosa and Thabo) however, showed some active engagement and cooperation while others were mostly silent and copying the written work from Thabo's book.

The group eventually agreed to use 12 as the height of the first triangle, only after the teacher's authoritative intervention. This gesture however was mainly indicative of the teacher's ritualised teaching which involved authoritative yet interactive or (at its extremes) non-interactive scaffolding which directly guided learners to follow what the teacher desired. The teacher's questions regarding 'how' the answer was obtained only invited the learners' narration of the computational procedure/formula or arithmetic process performed, not to probe them to elaborate or reason out on the choices made to perform the computations the way they did. This therefore provided learners with an opportunity to perform a ritual routine of following the rote procedures and formula use without substantiation on their computations.

In this problem-set part of the lesson, the learners were behaving accordingly with respect to the teaching activities provided to them. Their contribution in the overall learning process was mostly discussions over the correct side to be used as height, and the operation to perform to obtain the total Area for the 12-sided polygon. The problem which the learners were working on was designed in such a way that the accuracy of solutions would indicate their problem-solving skills and understanding of the two Mensuration concepts. However, much of the group members' discussions was purely on the dimensions (height) and Area of a triangle and how it contributes to the total Area of a regular polygon, these as stand-alone concepts (that is, separate from the problem-scenario provided). Therefore, the learners showed lack of problem-solving skills. In terms of skills in Mensuration as a concept, the group was observed to have severe deficiencies. Skills such as conceptual accuracy and calculations of Area were observed as lacking from the members of the group. While they showed a good memory of the formula, they were unable to use it accurately.

Teacher Pita's class teaching was organised somehow differently from the other three teachers. At the beginning of the lesson on Perimeter, teacher Pita explained and demonstrated the add-all-sides computational procedure for Perimeter of a square. Learners were then given an activity similar to the example to work on, which they correctly executed. The teacher's gesture of giving them the exercise similar to the example showed his ritual teaching routine which consequently instigated the learners' ritual performance since they strictly followed the example without any attempt to reason or elaborate. They showed good memory of the equal-sides property and the add-all-sides procedure for Perimeter since they were able to present their workings just like their teacher and they narrated the performed procedure accordingly.

In the additional exercise given, learners correctly used the demonstrated add-all-sides procedure for the Perimeter of some shapes including triangle. They however showed some incompetence in performing the arithmetic process with decimal numbers hence their discussion was on the addition process of these decimal numbers. During this discussion, learners' talk seemed structured and personalised as they talked of the addition of the digits, hence could be said to have used objectified discourse. Even so, their objectified short discourse could not be considered an exploration routine on the concept of Perimeter for which the computations were done. This is because the group discussed the arithmetic process separate from the concept of Perimeter for the shape in discussion. However, this objectified short talk was soon interrupted by teacher Pita through authoritative probing of learners through the addition process. The teacher's questions (and some rare explanations) were mostly about the process of addition and persistently consisted of the personal pronouns such as *'we'*, hence the talk was personalised. This processual and personalised talk authoritatively led and made it easy for the learners' talk to be processual and personalised (hence their disobjectified discourse). This therefore indicated the ritual nature of the routines of the discussants, teacher and the group of learners.

After a lengthy presentation on properties of a regular polygon, and the multiply-by-number-of-sides computational procedure for its Perimeter, the teacher ordered learners to discuss the exercise in their textbook. This required them to recognise the number of sides of each polygon and suggest the procedure they would use to find its Perimeter. Learners tried to be explorative and brainstormed on the correct choice of sides and procedure. In their brainstorming, they suggested

measuring the length of sides to come up with Perimeter. However, the teacher authoritatively interrupted and ordered them not to do anything else but narrate the procedure, hence reminding learners the procedure by direct telling. Learners therefore had to follow suit by remembering the multiply-by-number-of-sides procedure and used it in their talk.

At some point during the lesson, the learners were given a problem-set to work on. The solution process required them to read and interpret the scenario, identify the sides of the irregular polygon which formed its Perimeter, then use them to solve the problem. The learners struggled to identify the sides (or lines) of the polygon which formed its Perimeter since they could not point the sides which were equal and those which were not. This indicated their lack of understanding of the concept of Perimeter and properties of regular and irregular polygons.

After a long while, with the learners struggling unsuccessfully, the teacher intervened and interpreted the scenario while reminding them the properties of the polygon. The teacher's interpretation involved showing them which sides were equal and which were not. With the new interpretations from the teacher, Neo's group proceeded with their discussion and seemed to have remembered the properties of the regular polygon which allowed them to recognise the sides of the polygon which were equal, hence began to add the sides in an attempt to find the required Perimeter. In their workings, they correctly applied the add-all-sides procedure and agreed on the correct final answer and its units. In addition to this, one groupmate applied a multiply-by-number-of-sides procedure as an alternative. As correct as it was, the alternative procedure was not accepted by the group since the rest of the groupmates went with the majority and used the add-all-sides procedure. The latter could be attributed to the fact that the teacher never demonstrated how the multiply-by-number-of-sides procedure combines with addition operation for irregular polygons which have groups of equal sides. The learners' incompetence here could therefore be interpreted as ritual routines performance due to dependence on teacher's explanations and demonstrated procedures.

In another incident, a group of learners worked on a problem requiring calculation of the Area of the given polygon. While on the brainstorming session, some groupmates insisted that whenever the question says Area they need to use 'Length times Width'. However, this idea was quickly

abandoned and the group went on trying to relate the words in the problem-scenario. The discussion lacked any kind of structure and direction. The group eventually admitted to having a problem and surrendered claiming that the teacher would have to come to explain to them. As much as the teacher had not yet taught his class the concept of Area, the learners' discourse on the appropriate procedure lacked structure and included much of non-mathematical terms or any closer relation to the problem-scenario. The discourse involved mathematical words and words from the problem-scenario (for example, yard, sheep, Area, twelve-sided, regular polygon, calculate) yet there was no structure, endorsed narratives or any indication of understanding the problem. The learners' discourses, therefore, were mostly colloquial and indicated the learners' dependence on the teacher's authoritative intervention.

11.2.4 Sub-Research question 4: *How do teachers and learners interact during the teaching-learning of Mensuration concepts (Perimeter and Area)?*

The way in which the teacher interacts with learners during his explanations or discussions may help in describing the type of instructional or learning environment learners are exposed to. Studying these interactions could further determine if such environments offered learners enough opportunities to be autonomous in their learning. These interactions were analysed from the teacher-learner conversations during the teaching process where explanations and communication are required for clarification of the concept under discussion.

The interactions were viewed considering the types of communicative approaches deployed in the link-making or overall conversation, and the types of link-making processes made, as well as who –, between the teacher and learners – took part in the link-making processes. The study's focus and hence the analysis, was sharpened further by Scott *et al.* (2011) who postulated that in order to enable and nurture learners' deep conceptual understanding of scientific knowledge through teaching, they should be given an opportunity to carry out the process of link-making for and by themselves on the psychological and social plane. This therefore, is seen as a way to offer learners a chance to take responsibility for their own learning. Considering the Vygotskyan perspective of learning of scientific conceptual knowledge as an engagement in transition from interactive social environment to personal attribution, for Scott *et al*, the teacher is thus commented to enforce the learners' process of link-making through social interactions as a way to support their personal

construction of such conceptual links whenever confronted with the need to. As Scott *et al.* rightfully put it, "if link-making is not addressed through teaching, then it is unlikely to emerge in students' learning" (p.5).

With regard to the teacher-interaction during the teaching process, the analysis revealed that teachers made a number of pedagogical links in trying to elucidate their explanations on the taught concepts. The teacher's ability to make pedagogical links in their teaching of the Mensuration concepts showed some level of content and pedagogical knowledge of these concepts. However, contrary to the curricular expectations on proposed instructional practices, teachers predominantly took charge in the link-making explanations as opposed to involving learners in such explanations. The four teachers produced an average of six link-making incidents per teacher while only involving learners, in about one incident. Those who actually involved learners, did so by leading them in a question-answer talk over such explanations.

For instance, somehow similar to Nkoe, Teko produced six link-making explanations all of which were link-making to support knowledge building and included:

- making links to develop the scientific story at a macro level;
- making links between modes of representation (definition of Perimeter and the computational procedure for Perimeter);
- making links between modes of representation (definition and computational procedure of Area);
- making links between modes of representation (definition of Area, its graphical representation and counting squares procedure);
- analogic link-making (the standing-spread-legs analogy to explain height of triangle); and
- making links between modes of representation (definition Area and counting-squares computational procedure).

In these link-making explanations, the teacher led a unidirectional presentation as a concluding statement after some interactive talk with learners. This is with the exception of one incident where the teacher involved learners in a persistent question-answer probe to lead them into producing a

link-making narrative which connects the definition of perimeter and the computational procedure thereof.

The teachers' dominance in the link-making narrative production added to the contention that they preferred a direct instructional approach as opposed to the reform-oriented active approach proposed by the curriculum. For all these teachers, this dominance was further made explicit by their frequent use of non-interactive/authoritative and interactive/authoritative communicative approaches observed either during the link-making talk or between the link-making narrative production moments. For example, in somehow similar frequency to Pita, Nthabi's teaching involved a total of 21 incidents of communicative approach, three of non-interactive/authoritative, 16 of interactive/authoritative, and two of interactive/dialogic communicative approach. This indicated further that though teachers still involved learners in the classroom talk over the discussed concept, this was minimal hence implying their preference of non-reform-oriented approach. Thus, learners could be concluded to have been offered very limited opportunities to be autonomous in their mathematics learning.

The outcome shown in this summary of the study's analysis indicates the teachers' classroom interactions to predominantly involve interactive/authoritative communicative approach, and a number of link-making explanations which were mainly executed by the teachers. This implies that, even though the link-making explanations or elaborations are the critical moments in the teaching and learning process, the four teachers performed in a more traditional manner where the teacher is the centre of all information, while learners are passive recipients of such information. Not disregarding those rare moments where learners were guided by questions to arrive at the link-making explanations, the observed interactions between teachers and learners showed that the reform-oriented practices had not yet been adopted by the four teachers.

As articulated earlier by Brodie (2007), it therefore showed a misalignment to the reform-oriented instructional practices proposed by the new curriculum which these teachers were implementing. In the present findings, the teachers' dominant and persistent act of overtaking the classroom talk by mostly providing one-directional authoritative explanations where link-making processes had to take place could be attributed to their practice as what Pianta and Hamre (2009) referred to as

"insensitivity and a failure on the part of the teacher to respect and support (appropriately) the very powerful drive toward autonomy and a sense of competence" (p.4) for learners.

These findings align with Song *et al.* (2023) whose study found that at secondary school and high school classrooms, teachers involved learners in skewed high-cognitive dialogues compared to primary schools. The dialogues at secondary and high schools would require learners' high reasoning power, hence teachers had to take the greater part of the talk (more authoritatively) in order to get the learners to that level of communicative participation and make their grasp of the concept or the related computational procedure easy.

As indicated earlier, for each of the four observed teachers, though in rare cases, there were moments where communicative interactions involved teacher-learner probe either as a way to drive learners towards the link-making explanation or to help them produce such explanation. For example, in the isolated cases of the three teachers, Nthabi, Nkoe, and Pita, especially Nkoe's class, learners were persistently probed with leading questions to make the link between and distinguish Perimeter from Area of a rectangle. The use of a question *'How much Area… is enclosed in that Perimeter?'* which came as a way of showing learners the difference between the previously calculated Perimeter of such a rectangle and the Area which learners had to calculate. This could be referred somewhat as a follow-up which combines Brodie's (2011) *insert* and *press* codes since the teacher demanded learners to calculate the Area as a new concept with reference to a different but previously calculated concept of Perimeter; all this as a way to help learners make the link and distinguish between the two concepts.

On the same issue, teacher Teko's interaction with learners involved a considerable number of incidents where interactive/dialogic communicative approach took place and in some cases where the learners were probed to produce the link-making explanation. This was probably made possible by the fact that the learners had studied the concepts in their prior grades hence the present lesson became a review-and-practice lesson. Thus, the teacher had to drive them through question-answer interaction to make links in their learning. As Ayuwanti *et al.* (2021) found in their study, the oral questioning in Teko's teaching helped in focusing their attention on the learning material (this case the problem-set). However, this is different from the findings by Ayuwanti *et al.* (2021) where

questioning only happened before and after the teacher's 'delivering' the new concept. Teko's questioning occurred during the deliberations on the concept under focus, and was focused at 'confirming' or 'rejecting' learners' answers, 'maintaining' what learners suggested, and 'pressing' for further elaboration and substantiation on their correct or incorrect answers (whereby questioning on incorrect answers was aimed at making the learners to correct it hence funnelling) (Brodie, 2011).

Besides mostly counter-supporting the proposed curricular practices, the teacher's interaction practices in this study contrast the findings by Brodie (2011). That is, in Brodie (2011), the findings revealed that teachers showed a clear and greater shift in their 'moves', towards more reform-oriented interactions, though there were still minor incidents where they used traditional ways of delivering the content to learners. However, in the present study, teachers were mostly leading the interactions in a more authoritative and traditionally oriented delivery of concepts to learners who acted as passive recipients of the information.

11.2.5 Sub-Research question 5: *How do the Grade 8 mathematics teachers understand their role in the implementation of LAE-oriented curriculum in teaching Mensuration?*

The teachers' understanding or perspective of their role in implementation of the curriculum can describe their readiness and capability to abide by its demands. This was analysed from each teacher's observed dominant instructional approaches, their most visible teaching routines, and ways of interacting with learners, hence their observed likelihood of creating opportunities for learners' autonomous learning with the ultimate aim to create learner-autonomous environments (LAE). This was also reflected in the way they verbally described the expectations of the curriculum and their preferred instructional approaches, and how they verbally described their roles as reflection from the observed lessons.

As discussed in Section **11.2.1,** the analysis in the study revealed that all the four teachers' mostly used direct instructional approach during their teaching. In all these teachers' classes, especially in Nthabi, Nkoe, and Pita's, learners were provided with definitions, formulae, worked-examples and in certain instances some authoritative question-answer interaction over arithmetic processes on numerical digits. These types of instructional practices therefore describe the teachers as

content deliverers while learners are conceived as passive and empty receivers of such content. Therefore, the teachers could be interpreted to understand their role as knowledge-bearers and their duty being to display this knowledge to their learners as a way of trying to give this knowledge to them. This is a direct opposite of teachers' role in Agustin & Tindowen's (2019) study on Outcomes-based education (OBE) where teachers designed learner-centred activities including creating instructional materials and 'obedized' (to suit the OBE system) work texts as a way to improve learners' achievement in solid Mensuration.

In the case of teacher Teko, the lessons were driven by some discussions guided by the teacher's questions which steered learners into remembering the critical attributes of each concept they were discussing including the properties of some polygons. As a result, even though there were still many actions of direct instructional approach in his lessons, his attempts to act as a facilitator –as opposed to a knowledge-bearer and deliverer by stimulating learner discussions through progressive questioning – were hugely noticeable. To some extent, Teko's practice partially emulated '*Mr Ronaldo'*s' practices in Molefe and Brodie's (2010) study where learners were offered opportunities to argumentatively substantiate their answers without direct indication of their correctness as he progressively questioned them.

Though teacher Nkoe began one of his lessons with a learners' practical activity outside of the classroom, the majority of his actions before, during and after the practical session were of direct instructional nature, hence he could not be interpreted as any different from the other two teachers. From each teacher's class, a number of incidents were noticed where learners were engaged actively through questioning, activities and problems that demanded their thinking or suggestions, their hands-on participation and, to some degree, their collaborative reasoning. This indicated that though revealed at a lower scale, teachers still considered engaging learners to constructively develop their knowledge. Even so, since these active-approach incidents were rare, they were dominated by the actions of direct-teacher directed actions, making the teachers traditional approach performers. In Jameel and Ali's (2016) study, these kind of instructional practices that lack active engagement of learners through written exercises contribute to learners' poor performance in mathematics.

In addition to the types of instructional approaches, the teachers' understanding of their role in implementing the curriculum was characterised by the ritual teaching routines which in most cases were enforced by the disobjectified (processual and personalised) discourses over the concepts, Perimeter and Area (discussed in Section **11.2.2**). In contrast to this, Johansson and Österholm (2019) found that teachers' discourses were mostly objectified, though they found that this level of mathematical talk made it difficult for learners to participate since they had not attained that level of conceptualisation themselves. This therefore explains why it became so easy for the learners' discourse to be disobjectified hence their performance of ritual routines.

Furthermore, the discussion in Section **11.2.4** indicates that as much as in some instances in each teacher's class learners were engaged in interactive/dialogic communication (including rare involvement in link-making discussions and explanations) over the subject matter, all the teachers dominated the discussions hence making the interactions more teacher-dependent. This further described the teachers' consideration of themselves as knowledge-bearers and deliverers which is a more traditionally oriented perspective in contrast to the proposed curricular expectations. This therefore showed misalignment with the types of instructional approaches – as proposed by the Curriculum and Assessment Policy (CAP) – which are of active nature and mostly promote learners' autonomy in mathematics learning.

However, in their responses to the interview questions, each of the teachers indicated that even though the curriculum is 'good' (signified by syllabus topics and learning outcomes), it is of a higher complexity in relation to the Grade 8 learners' level, with others emphasising that it was not well introduced since no capacitation was provided for teachers. They, however, showed that the curricular expectations favour active and independent learning on the side of learners and active and autonomy-promoting instructional approaches. They blamed the learners' incompetence and the high-stakes nature of curriculum for their preference of a more direct and teacher-dominated instructional approach. This therefore indicated that the teachers considered themselves as knowledge bearers and problem-solvers, thus they make the content easy to understand for learners by providing a more direct and teacher-directed teaching. This corroborates their observed inclination towards traditionally-oriented instructional practices. This maintains the conclusion, presented a decade ago by Qhobela and Moru (2014), that teachers seemed to utter verbally and

accurately what is expected of them whilst they never implemented such expectations in their classrooms, with learners' weaknesses and lack of enthusiasm as substantiation for their preferred classroom practices.

11.3 Addressing the Main Research Question

Guided by the interpretation of the findings discussed under each sub-research question in Section 10.2, I present my understanding of the four teachers' classroom environment as an attempt to address the main research question: ***What is the nature of Grade 8 classroom environments created by mathematics teachers as they work towards implementation of the integrated curriculum, which calls for LAE (focusing on Mensuration)?***

11.3.1 The Study's Conclusions

In line with the curricular expectations, some of the teachers defined learner-autonomy, in a mathematics classroom, as a situation in which learners are given first priority hence allowed to take responsibility for their own learning. However, they were found to predominantly use direct instructional approach characterised by teaching actions which put the teacher on the spotlight as the knowledge deliverer while leaving learners as passive recipients of content. The delivery is activated by teachers' strict prompts which are focused at drilling learners for mastery and rote use of procedures.

Teachers were also found to participate in ritual teaching routines and their discourses, during their presentations and when attending learners' difficulties, as mostly colloquial and disobjectified (processual and personalised). The latter further suggested their reliance on ritual routines. These routines and discourses, as discussed under the reviewed literature, denied learners the opportunity to exploratively and independently participate in their mathematics learning, and they failed to enculturate (or show a progressive attempt to enculturate) learners into the mathematical ways of talking and doing mathematics, a process Sfard (2008) called mathematization.

These results of ritualisation, which came as a product of teaching, were evident in learners': dependence on teacher-provided or demonstrated procedures and rote use of given formulae, accompanied by difficulties in performing arithmetic processes; failure to interpret problem-

scenarios that connect real-life situations with the taught concepts of Mensuration; demonstration of their actions as mirror images of their teachers' actions executed to please the teacher for praising or to avoid punishment (Lavie *et al.*, 2019), and their discourses and routines showing no improvement in terms of deritualisation and objectification (Sfard, 2008). This therefore did not reflect learners who were autonomous or had the opportunity to be, both presently and progressively. This perspective however, does not leave unnoticed those rare incidents where learners showed attempts of being independently explorative in their learning actions and the rare cases where they tried to objectify the arithmetic processes executed, though these were executed independent of the Mensuration concepts, which were the key focus of the discussion.

The teachers' preference for direct instructional approach, which bore all the characteristics of what are commonly referred to as traditional teaching methods, also emanated from their adoption of the interactive/authoritative communicative approach (in many instances) livened up by rare instances of non-interactive/authoritative communicative approach. This was further evidenced by teachers' choice of executing the link-making explanations as a way to deliver knowledge to learners. It was also reflected in their interview utterances where they labelled learners as weak and below curricular-perceived level of intellect hence forcing them (teachers) to use direct instructional approach advanced by teacher-dominated communicative interactions. The latter teacher utterance however contradicts their statements about learners as 'active and independent' which came up informally in discussions prior to the present study (see Section 1.4).

While highlighting the teachers' preference of teacher-dominated practices, it is only fair to mention their rare use of some reform-oriented (Brodie, 2011) instructional practices. These were noticed in instances where each of the teachers used active instructional approach, tried to be explorative in probing learners, participated in discourses which could be regarded as formal and objectified; and lead learners to link-making explanations by question-answer interaction, including a rare use of interactive/dialogic communicative approach which offered learners the opportunity to actively, interactively, exploratively and independently participate in their knowledge development and enculturation into objectified mathematical talk. In contrast to the study by Molefe and Brodie (2010) where teachers' practices were found to be mostly reform-oriented while there still existed rare incidents of traditionally-oriented teaching practices, teachers

in the present study mainly displayed traditionally-oriented practices and rare reform-oriented practices.

Even though the four teachers' classroom environments could be regarded as similar in many ways, each of the discussed practices were executed differently and the lesson sequencing of presentations was different in each teacher's class. The resultant learner participation practices also were different and dependent on each teacher's instructional practices. For instance, in Nthabi's class, learners were told previously to read on the concept of Perimeter as preparation of the first lesson, hence the teacher's questions were posed with the expectation that the learners had memorised the definition and computation procedure. Therefore, the question-answer interaction was mostly comprised of teacher's authoritative explanations and was focused at what learners read, as opposed to stimulating their thinking and discussion on new concepts. Teko's class also depended on learners' prior experience with the concepts but this was a review of what they had learned in the previous grades, hence the questioning demanded their understanding of such concepts and properties of related polygons, however lacked the demand for confirmation of correct or incorrect answers.

Nkoe's class, on a different angle, started with a thorough brief on the usual shape of a 'site' in Lesotho and properties of a rectangle as such shape, hence the focus was on the perfection of the processes in the practical activity separate from the concept of Perimeter. This was evidenced by the teacher's post-practical explanations on the definition of Perimeter and its formula which did not relate to the practical activity performed.

It is therefore admissible in this study that the four teachers operated differently at a deeper level of their: instructional approaches; discourse and routine performances; teacher-learner interactions; and the level of competence of their learners (on conceptual understanding versus rote performance of procedures and formulae use, and their routines and mathematization of their talk). It is however concluded that while these differences in deeper-level operational performances existed, the general overview of each teacher's instructional practices suggested that their operations were mostly skewed towards the traditionally-oriented instructional practices than the expected reform-oriented practices.

Each of the four classroom environments therefore failed to provide learners with enough opportunities to be autonomous in their knowledge development on the Mensuration concepts which were the focus of the study. While the teachers blamed –,for their observed practices –,the complexity of the curricular content, weaker and low-intellect learners, and unplanned implementation of the curriculum, what was observable was that they were probably stuck in their 'old usual' ways of conducting their mathematics teaching, where teachers' knowledge and expertise in mathematics is evidenced by a display of intensive explanations with a series of examples to demonstrate how a certain procedure is performed or how a certain concept is defined and distinguished from others. Some of these teachers showed lack of knowledge of learner-autonomy hence obviously could not be expected to effectively implement a curriculum that emphasises LA. On the other hand, some of the teachers uttered correctly what was expected of them by the curriculum, but did not appropriately implement it.

This concluding contention also holds for the two teachers who participated in the Pilot study. They similarly presented their lessons involving direct instructional approach (backed and corroborated by their interview responses), and their teaching routines were rituals. Their teaching actions mostly engaged learners superficially by memorisation and rote use of demonstrated formulae and procedures. These, however, occurred differently in each teacher's class. Their differences were more visible where Teacher 1 rarely involved some actions of active instructional approach which were not observed in Teacher 2's class. Since each teacher introduced the formula of triangle ritually as half of the Area of a rectangle, learners in their classes showed lack of understanding of the concept and adhered to the procedure of dividing Area by two as a ritual (a rule/method to stick to always). The learners therefore were ritual performers who also showed incompetence in computational accuracy, and discourse objectification. Thus the classroom environments created by these teachers could be concluded to have not availed enough opportunities for learners to be autonomous in their mathematical knowledge development.

As part of the knowledge contribution and the conclusive contention, especially in the local context and in mathematics education (teaching and learning), the study introduces the LAMLE+Plus model (Figure 6) which is attributed to the study of LAE and practical directions into the

curriculum implementation. For this model, and resultant from the study's data analysis (through the LAMLE framework), it is concluded that, in addition to the learner-centred pedagogical practices (active instructional approach, objectification of discourses and explorative routine practice (as a way of mathematisation), and explorative involvement of learners in link-making through dialogic/interactive communicative approach), creating a learner autonomous mathematics learning environment could benefit from the use of, and allowing learners to use, learners' home language, using problem-solving as an instructional approach, and using real-life situational teaching. The LAMLE+Plus model is discussed further in section 11.3.2 below.

11.3.2 The Study's Knowledge Contribution

This PhD study, therefore, is deemed to have made a knowledge contribution towards practical antecedents and anti-antecedents of a Learner-Autonomous Environment (LAE) in the teaching and learning of mathematics, especially in recent school contexts and curricular change era where learners are envisioned to take greater responsibility for their mathematics learning as a way to prepare them for real-life matters requiring robust mathematical knowledge. It is understood, in this study, that an anti-LAE classroom environment would be characterised by: direct teacher-dominated instructional approaches; ritual-oriented teaching and mostly colloquial disobjectified (processual and personalised) discourses; mostly non-interactive/authoritative and interactive/authoritative communication; lack of learner opportunities to construct critical knowledge links; and lack of focus on learners' conceptual understanding, competence and deritualisation which includes mathematization through objectification.

The obvious counter perspective is that a LAE-oriented mathematics classroom would be characterised by: teacher's use of active learner-engaging instructional approaches; exploration-oriented teaching guided through objectified mathematical discourses; mostly interactive/dialogic communication; explorative guide of learners to produce link-making narratives while using appropriate visual mediators; and a focus on learners' development of conceptual understanding, competences, deritualisation and objectification of mathematics concepts.

One of the critical antecedents of LAE, revealed by the study, is the use of learners' home language, either as part of a translanguaging (Makonye, 2019) move or communicative interaction

where a general talk on mathematical objects is in learners' most accessible language while maintaining the key mathematical terminology (for example, Perimeter) in English language.

The study further contributes by proposing the LAMLE+Plus model (based on the conceptual framework presented in Chapter 3), now with the inclusion of Accessibility and Application of mathematics knowledge, as a lens in studying the promotion and presence of learner-autonomous classroom environments in mathematics teaching, especially if learners' responsibility, conceptual understanding, competence, deritualisation and mathematisation are in focus. It is also proposed as a tool to direct the practices and focus of teachers and education administration when implementing the reformed curriculum which focuses on learners' active conceptual development and progressive autonomy as highlighted by Lesotho's CAP. **Figure 6** presents the schematic structure of the proposed LAMLE+Plus model.

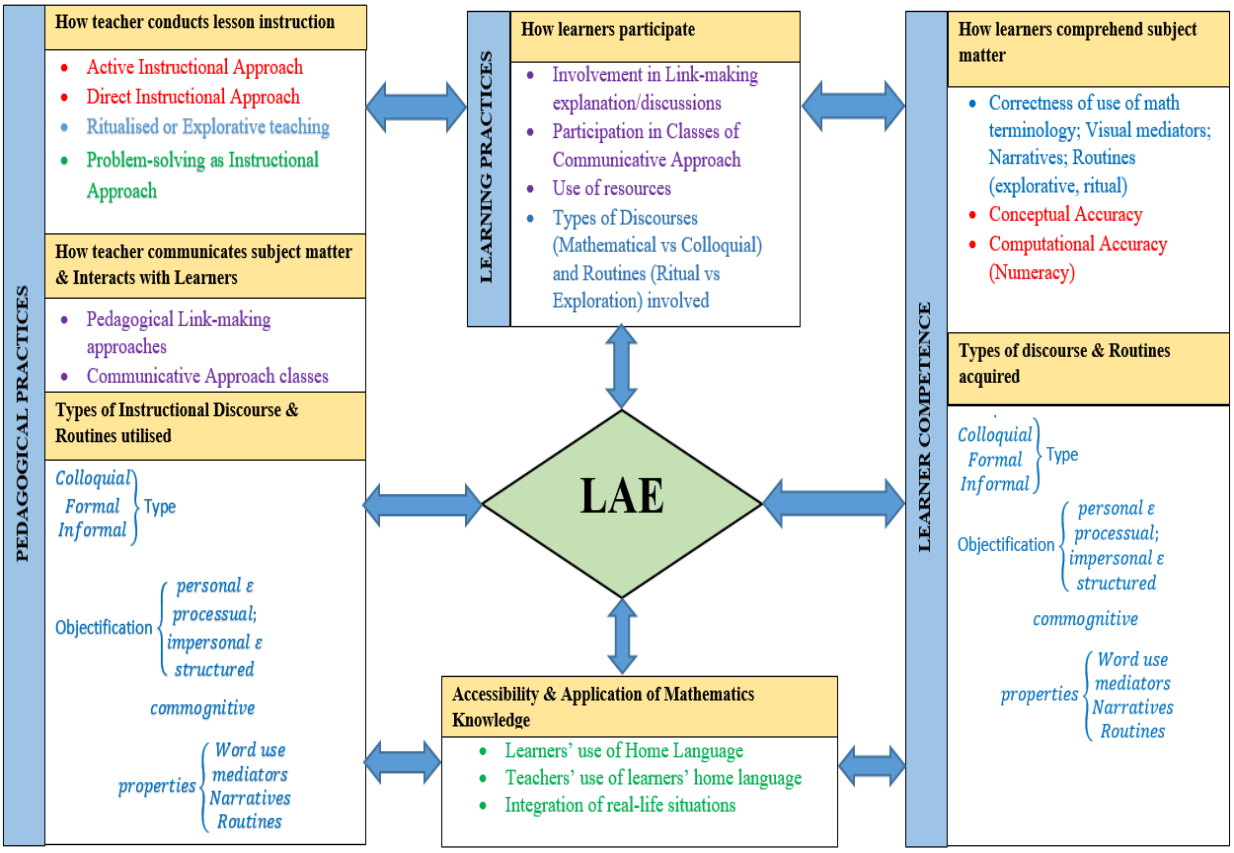


Figure 6: The LAMLE+Plus model for study of LAE and practical direction into curricula implementation

Figure 6 shows that in addition to LAMLE attributes' contribution to promoting learner-autonomy in a mathematics classroom, aspects of accessibility and applicability of mathematics knowledge (language and real-life situations) by the learner are critical for creation and promotion of Learner-Autonomous Classroom Environments. As suggested by the analysis in this study, learners' use of home language maximises their chances to be autonomous and explorative. I therefore suggest that teachers allow and use learners' home language to maximise their conceptual understanding which is attributed by their autonomy.

Revealed herein, is the learners' persistent failure to connect real-life situations to classroom-taught mathematics and to perform explorative activities to solve the real-life related problems. I therefore further suggest problem-solving as an instructional approach and frequent inclusion of real-life situations as authentic grounds for contextualising mathematics concepts for learners' enhanced comprehension of such concepts, especially Mensuration concepts. This improved model, therefore, could be used as a tool for studying the implementation of a LAE-oriented curriculum and for teachers' self-evaluation on learner-autonomous concept-based instruction in the teaching of mathematics.

11.4 Recommendations of the study

Based on the findings and discussions in the study, some recommendations are provided in relation to: the reform-oriented teaching of Mensuration concepts; the teachers training for pre- and in-service professional development and preparation for reform-oriented curriculum implementation; and implementation of the new curriculum and development of policies with respect to curricular change and ground operation of education.

11.4.1 Teaching Mensuration Concepts

Mensuration is a mathematics topic which deals with measurements and use of formulae which are related to the concepts of Perimeter, Area and Volume. Therefore, as revealed by the study, it becomes easy for teachers to teach learners towards memorisation and rote use of such formulae with limited (or no) focus on their deeper understanding of each concept. It is therefore recommended that teachers focus on the learners' development of conceptual understanding of

each concept, beyond memorisation of definitions, procedural derivation of each formula, and rote use of such formulae.

This could be achieved through teaching that is driven by open questions which demand learners to provide their thinking and reasoning over a concept and how it links with the real-life objects or other knowledge forms. Such teaching should therefore involve more reform-oriented instructional approaches such as active instructional approach where learners engage actively in their learning by manipulation of concrete objects and argumentative reasoning. It should also include explorative questioning which allows learners to deploy exploration as their learning routine. Though it may seem difficult and complicating learners' way of learning, the reform-oriented teaching on Mensuration should involve teachers' objectified discourse which will enculturate learners in the mathematical way of talking hence boost their confidence in the field.

To make this possible, the teacher-learner interactions should exploratively and progressively allow learners to contribute towards the link-making explanations and discussions, guided by interactive/dialogic teacher-learner communication, hence nurturing their argumentative reasoning over the mathematical objects. Additionally, the teaching should involve learners' real-life experiences and situations familiar to them and allow the use of their home language interchangeably with English which happens to be the local mandatory instructional language. The progressive nature of the education system may suggest that learners have not gained enough knowledge needed for this type of participation, but if well-structured and teachers are trained and prepared to develop learners' knowledge of mathematics this way, this may be a success.

11.4.2 Mathematics Teachers' Training: Pre- and In-service Professional Development

The most experienced teachers in the field, or those who have been in the field for a long time, may consider themselves knowledgeable enough to handle and execute the implementation of any reformed curriculum. However, I believe that every teacher must attend some professional development programmes in order to remain rejuvenated and skilled, and gain the ability and flexibility to abide with the changing curricula and types of learners obligated by the changing times and common practices among societies. It is recommended that the Ministry of Education and Training regularly organise and implement professional development programmes which are

intended to equip teachers with improved and reform-oriented teaching strategies, especially during every curriculum change era.

I recommend that teachers be provided with a financially sponsored professional development training to capacitate them with the curricular-proposed instructional approaches and general practices hence aim for perfection in the implementation of the curriculum. In particular, teachers should be fully acquainted with the concept of learner-autonomy in a mathematics classroom as a vital attribute in learners' development, which is acquired from specific instructional and learning practices (for instance, active instructional approach, explorative teaching routines, interactive/dialogic communication, learners' deritualisation, and discourse objectification).

The teacher-training institutions should familiarise themselves with the demands and expectations of the new curriculum hence structure their teacher-programmes such that student-teachers are prepared timely for effective implementation of the curriculum. Such programmes should include equipping student-teachers with reform-oriented instructional practices (with learner-autonomy in focus) in the teaching of mathematics, and new developments across the subject matter which they will soon teach in the field.

11.4.3 Implementation of Curriculum and Policy development

As indicated by the teachers in this study, the curriculum was not well introduced in terms of time and preparation of teachers, who were the prime custodians in its implementation. I therefore recommend that, as part of the implementation plan, the Ministry of Education and Training organise and provide workshops for teachers to familiarise them with the expectations of the new curriculum, especially the suggested reform-oriented teaching approaches, content adjustments and instructional practices in general. In addition to the introductory workshops, teachers should be visited regularly in their schools to monitor and ensure continuous maintenance of and adherence to the suggested teaching practices, and adherence to the upgraded mathematics content.

It is also recommended that the policy developers produce policy documents which are easy to read and are freely accessible to the teachers. Such documents should explicitly highlight what is expected of teachers and must clearly stipulate their self-evaluation procedures to assist teachers

to adhere and remain relevant to the new curricular expectations. To further improve the readability of the curricular documents, hence assisting teachers' understanding of their role in the implementation of the reform-oriented instructional practices, the curricular documents should include a glossary page where critical terminology, such as learner-autonomy, active instructional approach, and conceptual understanding, are explicitly defined and the teacher's role explicated. The reformed-policy-related syllabus should include a guide through the expected or suggested teaching approaches, strategies and methods for the teaching of each of the topics in the syllabus. This is to help teachers to refrain from the traditionalist way of teaching and adhere to the new suggested approaches which promote and nurture learner-autonomous development.

11.5 Limitations of the Study and Suggestions for Further Research

The study had some limitations which could mostly be attributed to the methodological preferences undertaken. The learners' classroom practices and problem-solving skills and competences may depend on how they were taught in the lower grades (Grade 6 and 7 or lower) during the early implementation stages of the curriculum. The study therefore could not generalise on whether their actions were strictly induced by implementation practices in Grade 8. The study could be more informative on this subject if it was longitudinal from the lower grades to Grade 8 and beyond.

The study collected and analysed data through teacher's interviews and classroom observations only. The study could benefit considerably if additional data was collected by looking into the teachers' lesson plans with a focus on the teacher activities and learner activities to analyse if teachers planned for direct conventional approach or active instructional approach and how their plans reflect their understanding of LA and their role in LAE.

Furthermore, the data on learners' practices and competences and its analysis depended only on observations during the actual lessons. The analysis could be further illuminating if the learners were interviewed as a way of allowing them to substantiate their actions, ways of communicating (discourses and routines) and their interactions with teachers. The study could further illuminate on learners' competences (conceptual understanding, computational and procedural accuracy) and discursive routines (ritual vs explorations, and mathematical objectified vs processual-

personalised discourse) if the learners' workings on the problem-set was marked and analysed for errors and other concept-related inconsistencies, in addition to the observed communication.

The study focused only on two instructional approaches, active and direct instructional approaches, while there could exist many instructional approaches available in the literature. Since the study was explorative, it could have further explored different instructional approaches as they emanate from the classroom observations, hence deploy inductive analysis of related data to reveal such instructional practices. This could also eliminate the analysis restrictions into active versus direct instructional approach and broaden to reform-oriented versus traditionalist instructional practices which could later be related to the concept of learner-autonomy.

The study gathered data from classrooms through observation of only three lessons per teacher and with only four teachers, which occurred within a very short period of time due to limited time for completion of the PhD study. Had there been enough time, the study could have used more teachers from different districts and contexts, and each teacher observed in several lessons for deeper observation of their practices. In addition, the study involved only four teachers due to the fact that the fifth had a class which was noisy and chaotic, hence the teacher-learner and learner-learner communication could not be easily recorded. The number of teachers was also limited due to the type of study, qualitative, and the amount of data and depth of analysis that would be undertaken. That is to say, due to the limited amount of time required and the limited finances for me to complete the PhD study, the study had to use only these four teachers, and only those nearest to me to minimise travel time and costs.

One of the findings that emerged from the data analysis was the learners' ability to expose their levels of understanding of the concepts (Perimeter and/or Area) and levels of autonomy in their learning when they were communicating in their home language. As discussed in several sections in this chapter (for instance, Section 11.2.3) this implied that, to some extent, learners engaged in translanguaging to negotiate their mathematics learning. However, the concept of translanguaging in this study was not part of the focus, data analysis or analytical tool, hence it was only introduced to strengthen the discussion on learners' use of their home language and the implication of this to the degree of their mathematics learning autonomy. The concept is therefore discussed minimally

without a thorough examination. As a result, and in view of the value of language in the teaching-learning process, more research under a similar focus could further examine the concept of translanguaging in relation to learners' conceptual understanding of mathematics concepts and its influence on the learners' autonomy in mathematics learning.

While focusing on the concept of learner-autonomy, a further research study could focus on teacher and learner perceptions and beliefs in learner-autonomy in a mathematics classroom as a separate study before observations and closer interviews which could be consolidated later to analyse the effect or alignment of the perceptions and actual practices observed. Further studies could also focus on teachers' implementation practices with a longer duration using more observed lessons and more teachers across the country. These studies could also include how teachers carry out the assessment and whether they implement learners' peer assessment as a way of promoting their autonomy. Furthermore, while in the context of Lesotho secondary school education, a further research could measure learners' levels of autonomy in their mathematics learning and analyse its effect on their mathematics performance and mathematization (that is, enculturation into the mathematics way of talking – discourses and routines).

In conclusion, as curricula undergo periodical review in different contexts, the dynamics of teaching and learning require deep and constant engagement to ensure synergy with the planned and the enacted curriculum. It is through continuous reflections, observations and debates that academically rewarding learner-autonomous environments can be achieved to strengthen pedagogy.

REFERENCES

Abadi, A., & Amir, F. (2022). Analysis of the Elementary School Students Difficulties of in Solving Perimeter and Area Problems. *Jurnal Ilmiah Pendidikan Matematika, 10(2), 396-408*. DOI: 10.25273/jipm. v10i2.11053

Abulhul, Z. (2021). Teaching Strategies for Enhancing Student's Learning. *Journal of Practical Studies in Education, 2(3), 1-4*, DOI: https://doi.org/10.46809/jpse.v2i3.22

Adams, G., & Carnine, D. (2004). Direct instruction. *Handbook of learning disabilities*, 403-416.

Agustin, T. & Tindowen, J. (2019). Improving engineering students' achievement in solid mensuration by using an obedized work text. *Global Journal of Engineering Education, 21(1), 75 – 79.*

Akiha, K., Brigham, E., Couch, B., Lewin, J., Stains, M., Stetzer, M., Vinson, E. & Smith, M. (2018). What Types of instructional shifts Do students experience? Investigating active learning in science, Technology, engineering, and Math classes across Key Transition Points from Middle school to the University level. *Frontiers in Education, 2*, 1 – 18. doi: 10.3389/feduc.2017.00068.

Akwensi, K., Komla, D., Amanyi, C., Bornaa, S., Abugri, M., & Kombat, A. (2023). Effect of Geogebra Software on Students' Academic Performance in Mensuration at the Senior High School Level. *International Journal of Innovative Science and Research Technology, 8(7), 1509 – 1516.*

Akyuz & Stephan, M. (2020). Co-teaching practices that build autonomy for students with learning disabilities in mathematics. *International Journal of Mathematical Education in Science and Technology*, DOI: 10.1080/0020739X.2020.1795286

Ayuwanti, I., Marsigit, & Siswoyo, D. (2012). Teacher-student interaction in mathematics learning. *International Journal of Evaluation and Research in Education (IJERE)* 10, (2), 660~667. ISSN: 2252-8822, DOI: 10.11591/ijere. v10i2.21184

Bakker, A., Smit, J. & Wegerif, R. (2015). Scaffolding and dialogic teaching in Mathematics education: Introduction and review. *ZDM Mathematics Education 47; 1047–1065.*DOI 10.1007/s11858-015-0738-8

Barnes, J., Conrad, K., Demont-Heinrich, C., Graziano, M., Kowalski, D., Neufeld, J., Zamora, J., & Palmquist, M. (2012). *Generalizability and Transferability.* Writing@CSU. Colorado State University. http://writing.colostate.edu/guides/guide.cfm?guideid=65.

Bennet, C. (2019). The Logic of Learning. *Axiomathes, 29, 173–187;* https://doi.org/10.1007/s10516-018-9394-2

Benson, P. (2013). Teaching and researching: Autonomy in language learning. 2nd edition. London: Routledge.

Bingham, J. (2023). From data management to actionable findings: A five-phase process of qualitative data analysis. *International Journal of Qualitative Methods*, 22. 1–11 DOI: 10.1177/16094069231183620

Bjørkestøl, K., Borge, C., Goodchild, S., Nilsen, K., & Tonheim. M. (2021). Educating to inspire active learning approaches in mathematics in Norwegian universities. *MNT konferansen 2021 – UiA.*

Borg, S & Alshumaimeri, Y. (2017). Language learner autonomy in a tertiary context: Teachers' beliefs and practices. *Language Teaching Research, 23(1), 9-38.* ps://doi.org/10.1177/1362168817725759

Brahier, D., Leinwand, S. & Huinker, D. (2014). Principles to Actions: Mathematics Programs as the core for Student Learning. Mathematics Teaching in the Middle School; 107(19). DOI; 10.5951/mathteacmiddscho.19.9.0516

Brodie, K. (2007). Dialogue in mathematics classrooms: beyond question-and- answer methods. *Pythagoras 66, 3-13.*

Brodie, K. (2011). Working with learners' mathematical thinking: Towards a language of description for changing pedagogy. *Teaching and Teacher Education 27; 174 – 186, doi: 10.1016/j.tate.2010.07.014.*

Broward County Schools. (1974). Exemplary reading pro- grams: Title I reading center program. Fort Lauderdale, FL: Author. (ERIC Document Reproduction Service No. ED 108 148).

Canavarro, A.P. (2011). Ensino exploratório da Matemática: Práticas e desafios. Educação e Matemática. 115, 11-17.

Chand, S., Chaudhary, K., Prasad, A. & Chand, V. (2021). Perceived Causes of Students' Poor Performance in Mathematics: A Case Study at' Poornd Tavua Secondary Schools. *Frontiers in Applied Mathematics and Statistics, 7(614408), 1 – 13.* doi: 10.3389/fams.2021.614408

Chirayangyuenyong, S., Emarat, N., & Arayathanitkul, K. (2023). *Journal of Physics: Conference Series 2431 (2023) 012011, 1 – 4,* doi:10.1088/1742-6596/2431/1/012011

Cohen, L., Manion, L. & Morrison, K. (2007). *Research Methods in Education*. New York, Routledge.

Cohen, L., Manion, L. & Morrison, K. (2018). Research Methods in Education (8th ed). Routledge.

Confrey, J., Gianopulos, G., McGowan, W., Shah, M. & Belcher, M. (2017). Scaffolding learner-centered curricular coherence using learning maps and diagnostic assessments designed around Mathematics learning trajectories. *ZDM,* 49, 717–734. doi.org/10.1007/s11858-017-0869-1.

Creswell, J., & Poth, C. (2017). Qualitative inquiry and research design: Choosing among five approaches. Sage Publications.

Cretchley, G. & Castle, J. (2001). OBE, RPL and adult education: good bedfellows in higher education in South Africa? *International Journal of Lifelong Education, 20(6), 487-501,* DOI: 10.1080/02601370110088463

Denzin, N., & Lincoln, Y. (2011). The SAGE Handbook of Qualitative Research. Sage Publications.

De Vos, A., Strydom, H., Fouche', C. & Delport, C. (2005). Research at Grass Roots. For the Social Sciences and Human Services Professions (3rd ed). Van Schaik Publishers.

Doruk, B. (2014). The Educational Approaches of Turkish Pre-Service Elementary Mathematics Teachers in Their First Teaching Practices: Traditional or Constructivist? *Australian Journal of Teacher Education, 39(10);* http://dx.doi.org/10.14221/ajte.2014v39n10.8.

Dundon, P. & Chadwick, C. (2012). The effect of Learner Autonomy on student performance in GCSE Mathematics in a private school in Dubai, U.A.E. *Dissertation.* https://bspace.buid.ac.ae/bitstream/1234/180/1/90028.pdf

ECoL. (2018). JC Mathematics Report. Retrieved from, www.examcouncil.org.ls/Report. Retrieved on; 12 September 2020.

Ekwueme, O., Esther E. Ekon, E., & Ezenwa-Nebife, C. (2015). The Impact of Hands-On-Approach on Student Academic Performance in Basic Science and Mathematics. *Higher Education Studies; 5 (6), 47 – 51*. doi:10.5539/hes. v5n6p47

Essack, R. (2015). Exploring Grade 11 learners' routines on function from a commognitive perspective. *Doctoral Thesis*. University of Witwatersrand, Johannesburg.

Firmansyah, F., Gradini, E., Yustinanningrum, B., & Lubis, N. (2019). Comparison of The Implementation of Direct Instruction, Problem-Based Instruction, and Cooperative Learning using Cabri 3D on Geometry. In *Proceedings of the 5th Annual International Seminar on Trends in Science and Science Education, AISTSSE 2018, 18-19.*

Flick, M., & Kuchey, D. (2015). Contest corner: Increasing classroom discourse and computational fluency through number talks. *Ohio Journal of School Mathematics, 71, 38 – 41;* https://kb.osu.edu/bitstream/handle/1811/78915/1/OJSMFreeman, S., Eddy, L., Mcdonough, M., Smith, K., Okoroafor, N., Jordt, H., & Wenderoth, P. (2014). Active Learning Increases Students' Performance in Science, Engineering, and Mathematics. *Proceedings of the National Academy of Sciences of the United States of America, 111, 8410-8415*. http://www.pnas.org/content/111/23/8410.full.pdf

Fuat, F., Susanto, K., & Aini, F. (2020). Classificational and Theoretical Execution Misconceptions: Classification of Misconceptions Based on Students Concepts in Plane Geometry. *Journal of Education and Learning Mathematics Research (JELMaR), 1(2), 8-21*. https://doi.org/10.37303/jelmar.v1i2.20

Gambari, I., Shittu, A. & Taiwo, O. (2013). Enhancing student's understanding of algebra concepts through cooperative computer instruction. *Gazi Journal of Education,* 1(1), 29-43.

Gitaari, EME, Nyaga, G. Muthaa, G, & Reche, G. (2013). Factors Contributing to Students Poor Performance in Mathematics in Public Secondary Schools in Tharaka South District, Kenya. *Journal of Education and Practice, 4 (7), 93 – 99. http://www.iiste.org/Journals/index.php/JEP/article/view/5281*

Guba, E., & Lincoln, Y. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research,* 2(163-194).

Güçler, B. (2013). Examining the discourse on the limit concept in a beginning-level calculus classroom. *Educational Studies in Mathematics, 82(3), 439–453*. https:// doi.org/10.1007/s10649-012-9438-2.

Güçler, B. (2014). The role of symbols in mathematical communication: The case of the limit notation. *Research in Mathematics Education, 16(3), 251–268.* https://doi. org/10.1080/14794802.2014.919872.

Heyd-Metzuyanim, E. & Graven, M. (2019). Rituals and explorations in mathematical teaching and learning: introduction to the special issue. *Educational Studies in Mathematics*, 101:141–151 https://doi.org/10.1007/s10649-019-09890-x

Heyd-Metzuyanim, E., & Graven, M. (2016). Between people-pleasing and mathematizing: South African learners' struggle for numeracy. *Educational Studies in Mathematics, 91, 349–373*. https://doi.org/10.1007/s10649-015-9637-8

Heyd-Metzuyanim, E., Smith, M., Bill, V., & Resnick, B. (2018). From ritual to explorative participation in discourse-rich instructional practices: A case study of teacher learning through professional development. *Educational Studies in Mathematics*. https://doi.org/10.1007/s10649-018-9849-9

Heyd-Metzuyanim, E., Tabach, M., & Nachlieli, T. (2016). Opportunities for learning given to prospective mathematics teachers: between ritual and explorative instruction. *Journal of Mathematics Teacher Education, 19(6).* DOI 10.1007/s10857-015-9311-1

Hodgen, J., Foster, C., Marks, R., & Brown, M. (2018). Evidence for Review of Mathematics Teaching: *Improving Mathematics in Key Stages Two and Three*: Evidence Review. London: Education Endowment Foundation.

Jameel, T. & Ali, H. (2016). Causes of Poor Performance in Mathematics from Teachers, Parents and Student's Perspective. *American Scientific Research Journal for Engineering, Technology, and Sciences, 15(1), 122-136, ISSN (Online) 2313-4402*

Johansson, H., Österholm, M. (2019). Objectification of upper-secondary teachers' verbal discourse in relation to symbolic expressions. *Journal of Mathematical Behavior, (56), 1 – 14, https://doi.org/10.1016/j.jmathb.2019.100722*

Kim, D., Choi, S. & Lim, W. (2017). Sfard's Commognitive Framework as a Method of Discourse Analysis in Mathematics. *International Journal of Cognitive and Language Sciences, 11(11), 481 – 485.* doi.org/10.5281/zenodo.1132727

Khurshid, Z. (2017). Learners' autonomy - a critical study of its stance in the past, present and future pedagogies. *International Journal of English and Literature (IJEL), 7(2), 75-84.*

Kollar, I., Ufer, S., Reichersdorfer, E., Vogel, F., Fischer, F., & Reiss, K. (2014). Effects of collaboration scripts and heuristic worked examples on the acquisition of mathematical argumentation skills of teacher students with different levels of prior achievement. *Learning & Instruction 32, 22-36.* doi: 10.1016/j.learninstruc.2014.01.003

Konopka, L., Adaime, B. & Mosele, H. (2015) Active Teaching and Learning Methodologies: Some Considerations. *Creative Education*,**06**,1536-1545. doi: 10.4236/ce.2015.614154

Kudakwashe, M. & Sunzuma, M. (2016). The effectiveness of ethno-Mathematics and inclusion of models in the teaching and learning of geometry at 'o' level: A case of mensuration of solids at B & P study centre in Chitungwiza. *Honours degree dissertation (unpublished);* http://library.buse.ac.zw:8080/jspui/handle/123456789/6077

Lamas, E., Maria, A. & Gomes, M. (2010). Didactics–promoting collaborative work and personal learning environment. Critical, creative and autonomous roles in a competitive society. *Congres Internacional de DIDACTIQUES;398,1–8.* https://dugi-doc.udg.edu/bitstream/handle/10256/2939/398.pdf?sequence=1

Lavie, I., Steiner, A., & Sfard, A. (2019). Routines we live by: from ritual to exploration. *Educational Studies in Mathematics, 101:153–176. https://doi.org/10.1007/s10649-018-9817-4*

Leung, L. (2015). Validity, reliability, and generalizability in qualitative research. *J Family Med Prim Care*, 4(3), 324–327. doi: 10.4103/2249-4863.161306.

Lincoln, S. and Guba, G. (1985) words from Naturalistic Inquiry, copyright Sage Publications Inc., reprinted by permission of Sage Publications Inc.

Linneweber-Lammerskitten, H., Schäfer, M. & Samson, D. (2010). Visual Technology for the Autonomous Learning of Mathematics. *Pythagoras, 72, 27-35* http://pythagoras.org.za/index.php/pythagoras/article/download/18/14

Little, D. (2003). Learner autonomy and second/foreign language learning. *Centre for Languages Linguistics & Area studies*; https://www.llas.ac.uk/resources/gpg/1409

Lo, T. and Ruef, L. (2020). Student or Teacher? A Look at How Students Facilitate Public Sensemaking During Collaborative Groupwork. *Journal of Urban Mathematics Education 13(1), 15–33.*

Machaba, M. (2016). The concepts of area and perimeter: Insights and misconceptions of Grade 10 learners. *Pythagoras, 37(1), 1-11,* a304. http://dx.doi.org/10.4102/pythagoras. v37i1.304

Mahlaba, C., & Mudaly, V. (2022). Exploring the relationship between commognition and the Van Hiele theory for studying problem-solving discourse in Euclidean geometry education. *Pythagoras, 43(1),* a659. https://doi. org/10.4102/pythagoras. v43i1.659

Makalela, L. (2015). Moving out of linguistic boxes: The effects of translanguaging strategies for multilingual classrooms. *Language and Education 29(3): 200–217*. https://doi.org/10.1080/09500 782.2014.994524

Makonye, P. (2019). The effect of translanguaging in teaching the Grade 6 topics of perimeter and area in rural schools, Southern African Linguistics and Applied Language Studies, 37:3, 221-231, DOI: 10.2989/16073614.2019.1671880

Michel, N., Cater, J., & Varela, O. (2009). Active versus passive teaching styles: An empirical study of student learning outcomes. *Human resource development quarterly*, *20*(4), 397-418.

Mji.A, & Makgato, M. (2006). Factors associated with high school learners' poor performance: a spotlight on mathematics and physical science. *South African Journal of Education, 26 (2), 253 – 266.*

MoET. (2009). *Curriculum and Assessment Policy*: *Education for individual and social development.* Maseru: MoET.

MoET. (2017). Grade 8 Syllabi. National Curriculum Development Center. Maseru.

Molefe, N., & Brodie, K. (2010). Teaching mathematics in the context of curriculum change. *Pythagoras, 71, 3-12; DOI: 10.4102/pythagoras. v0i71.5*

Molina, G. & Bansil, G. (2018). Correlation between Confidence and Performance of Engineering Students in Solid Mensuration. People: *International Journal of Social Sciences, 4(1), 87-104. DOI-https://dx.doi.org/10.20319/pijss.2018.41.87104*

Mortimer, F. & Scott, H. (2003). *Meaning-making in secondary science classrooms*. Buckingham, UK: Open University Press.

Motseke, M. (2005). Obe: implementation problems in the black townships of south Africa. *Interim: Interdisciplinary Journal, 113-121*

Mudaly, V., & Mpofu, S. (2019). Learners' Views On Asymptotes of a Hyperbola and Exponential Function: A Commognitive Approach. *Problems of Education in the 21st Century*, 77(6), 734-744.

Mueller, M., Yankelewitz, D. & Maher, C. (2014). Teachers Promoting Student Mathematical Reasoning. *Investigations in Mathematics Learning, 7:2, 1 -20,* DOI: 10.1080/24727466.2014.11790339

Mulyanto, H., Gunarhadi, G. & Indriayu, M. (2018). The effect of problem-based learning model on student Mathematics learning outcomes viewed from critical thinking skills. *International Journal of Educational Research Review*, *3*(2), 37-45. DOI: 10.24331/ijere.408454

Nachlieli, T., & Tabach, M. (2018). Ritual-enabling opportunities-to-learn in mathematics classrooms. Educational Studies in Mathematics. https://doi.org/10.1007/s10649-018-9848-x

Nakata, Y. (2011). Teachers' readiness for promoting learner autonomy: A study of Japanese EFL high school teachers. *Teaching and Teacher Education,* 27(5), 900– 910. https://doi.org/10.1016/j.tate.2011.03.001

Nts'asa, L. & Machaba, F. (2019). An exploration of teaching strategies of core and extended curricula in teaching the concept of solids (mensuration): A case of three selected schools at Mafeteng district in Lesotho. *Proceedings of the 25th Annual National Congress of the Association for Mathematics Education of South Africa; 245 – 257.*

Ono, Y. & Ferreira, J. (2010). A case study of continuing teacher professional development through lesson study in South Africa. *South African Journal of Education, 30, 59-74,*

Otumudia, A. (2017). Hidden Facts in new SSCE Mathematics. Ughelli North, Delta State. Otumudia Publishers.

Petersen, I., & Gorman, S. (2014). "Strategies to Address Common Challenges When Teaching in an Active Learning Classroom." *New Directions for Teaching and Learning* 2014 (137): 63–70. https://doi.org/10.1002/tl.20086

Pezalla, A., Pettigrew, J. & Miller-Day, M. (2015). Researching the researcher-as-instrument: an exercise in interviewer self-reflexivity. *Qual Res; 12(2): 165–185.* doi:10.1177/1487941111422107.

Phuong, M. (2020). Measuring Conceptual Understanding, Procedural Fluency and Integrating Procedural and Conceptual Knowledge in Mathematical Problem Solving. *International Journal of Scientific Research and Management (IJSRM), 8(5), 1334-1350* DOI: 10.18535/ijsrm/v8i05.el02

Pianta, R.C. & Hamre, B. K. (2009). Classroom processes and positive youth development: Conceptualizing, measuring, and improving the capacity of interactions between teachers and students. *NEW DIRECTIONS FOR YOUTH DEVELOPMENT, 121,*.33 – 46; WILEY PERIODICALS, INC. Published online in Wiley InterScience, DOI: 10.1002/yd.295

Piccolo, D., Harbaugh, A., Carter, T., Capraro, M. & Capraro, R. (2008). Quality of instruction: Examining discourse in middle school Mathematics instruction. *Journal of Advanced Academics*, 19: 376–410. https://doi.org/10.4219/jaa-2008-809

Ponte, P. (2005). Gestão curricular em Matemática. In: GTI (Ed.) O professor e o desenvolvimento curricular Lisboa (pp. 11-34). APM.

Privitera, G. & Ahlgrim-Delzell, L. (2019). Research Methods for Education. SAGE Publications.

Qhobela, M. & Moru, E. (2020) Understanding the Use of Classroom Talk by Newly Trained Physics Teachers in Lesotho. *African Journal of Research in Mathematics, Science and Technology Education, 24:1, 81-91,* DOI: 10.1080/18117295.2020.1733194

Qhobela, M. & Moru, E. (2014). Understanding Challenges Physics Teachers Come Across as they Implement Learner-centred Approaches in Lesotho. *African Journal of Research in Mathematics, Science and Technology Education, 18(1), 63 - 74*. DOI: 10.1080/10288457.2014.884351

Qhobela, M. (2012). Using Argumentation as a Strategy of Promotion of Talking Science in a Physics Classroom: What Are Some of the Challenges? *US-China Education Review B 2, 163-172.*

Reeve, J. & Tseng, C. (2011). Agency as a fourth aspect of students' engagement during learning activities. *Contemporary Educational Psychology*, 36; 257–267.

Reeve, J. (2013). How Students Create Motivationally Supportive Learning Environments for themselves: The Concept of Agentic Engagement. *Journal of Educational Psychology, 105*(3), 579 – 595.

Reinders, H. & White, C. (2011). Commentary learner autonomy and new learning environments. *Language Learning & Technology; 15(3), 1–3*.

Richit, A., Tomkelski, M., & Richit, A. (2021). Understandings of perimeter and area mobilized with an exploratory approach in a lesson study. *ACTA SCIENTIAE, 23(5), 1-36, DOI: 10.17648/acta.scientiae.6226*

Rosenshine, B. (2008). Five meanings of direct instruction. *Center on Innovation & Improvement, Lincoln*, 1-10.

Rosita, A., Wardono, W. & Kartono, K. (2018). Discovery Learning - PMRI in Improving Mathematics Literacy of Junior High School Students. *Unnes Journal of Mathematics Education Research, 7 (1), 35 – 39*; https://journal.unnes.ac.id/sju/index.php/ujmer/article/view/23990/11125.

Sa'ad, U., Adamu, A., Sadiq. M. (2014). The Causes of Poor Performance in Mathematics among Public Senior Secondary School Students in Azare Metropolis of Bauchi State, Nigeria. *IOSR Journal of Research & Method in Education, 4 (6), 32 – 40*. DOI: 10.9790/7388-04633240Sachdeva, S. (2019). Students' experiences of learner autonomy in Mathematics classes. *Eleventh Congress of the European Society for Research in Mathematics Education*; https://hal.archives-ouvertes.fr/hal-02421636/document.

Salami, O., & Spangenberg, E. (2024). Impact of Cooperative Learning on Teaching Mensuration to Senior Secondary Students. *Interdisciplinary Journal of Education Research*, 6, 1-16. https://doi.org/10.38140/ijer-2024.vol6.18

Schwarz, B., Dreyfus, T., and Hershkowitz, R. (2011). Transformation of knowledge through classroom interaction. *Educational Studies in Mathematics, 76(1),101-115*

Scott, P., Mortimer, E., & Ametller, J. (2011). Pedagogical link-making: a fundamental aspect of teaching and learning scientific conceptual knowledge, *Studies in Science Education, 47:1, 3-36*, DOI: 10.1080/03057267.2011.549619

Šeďová, K., Švaříček, R., Sedláček, M. & Šalamounová, Z. (2014). On the way to Dialogic Teaching: Action Research as a Means to Change Classroom Discourse. *Studia paedagogica, 19(4), 9 - 43, DOI: 10.5817/SP2014-4-2.*

Sfard, A. (2016). Ritual for ritual, exploration for exploration: Or what learners are offered is what you get from them in return. *In J. Adler, & A. Sfard (Eds.).* Research for educational change: Transforming researchers' insights into improvement in mathematics teaching and learning (pp. 41–63). New York: Routledge.

Sfard, A. (2007). When the Rules of Discourse Change, but Nobody Tells You: Making Sense of Mathematics Learning from a Commognitive Standpoint. *The journal of the learning sciences, 16*(4), 567–615.

Sfard, A. (2008). Thinking as communicating: Human development, the growth of discourses, and mathematizing. New York, Cambridge University press.

Snell, J., & Lefstein, A. (2011). Computer-assisted systematic observation of classroom discourse and interaction. *Working Papers in Urban Language & Literacies*, 77, 1–28. Available from http://www.kcl.ac.uk/depsta/education/wpull.

Sochima, S. (2022). Efficacy of Constructivist's Teaching Method in Proving Mensuration Theorem: Implications for Nigeria Senior Secondary School Students. *Journal of Education and Vocational Research, 13(1), 21-32*

Song, Y. Shu Zhang, S. & Liu, B. (2023). Investigating the dialogic patterns of mathematics lessons in different stages of education, *The Journal of Educational Research, 116:2, 77-89,* DOI: 10.1080/00220671.2023.2192686

Steedly, K., Dragoo, K., Arafeh, S. & Luke, S. (2008). Effective Mathematics Instruction. Evidence for Education. *National Dissemination Center for Children with Disabilities (NICHCY), **3(1), 1 -11;*** https://files.eric.ed.gov/fulltext/ED572704.pdf.

Stefanou, C., Perncevich, K., DiCintio, M. & Turner, J. (2004). Supporting Autonomy in the Classroom: Ways teachers encourage students' decision making and ownership. *Educational Psychologist, 39(2), 97 – 110*.

Sun, S. (2023). The Effects of Learner Autonomy on Academic Performance Among Cambodian Students Studying English in Higher Education. *International Journal of Scientific and Research Publications, 13(6), 206-210. DOI: 10.29322/IJSRP.13.06. 2023.p1382*

Tainio, L., & Laine, A. (2015). Emotion work and affective stance in the mathematics classroom: the case of IRE sequences in Finnish classroom interaction. *Educational Studies in Mathematics, 89*, 67-87.

Talib, A. & Kailani, I. (2014). Problem based learning in cooperative situation (PBLCS) and its ımpact on development of personal ıntelligence. *International Journal of Evaluation and Research in Education (IJERE),* 3(4), 236-244.

Thomas, A. (2023). Class Size and Academic Performance of Senior Secondary School Students in Mensuration in Ogbomoso Education Zone. *International Journal of Education and Evaluation (IJEE), 2695-1940, 9(1),* DOI: 10.56201/ijee.v9.no1. 2023.pg10.20

Thuneberga, H., Salmia, H. & Bognerb, F. (2018). How creativity, autonomy and visual reasoning contribute to cognitive learning in a STEAM hands-on inquiry-based math module. *Thinking Skills and Creativity 29, 153–160.* doi.org/10.1016/j.tsc.2018.07.003

Tunji-Olayeni, P., Kajimo – Shakantu, K., Ayodele, T. & Emmanuela, K. (2021). Factors Affecting Students' Learning in Civil Engineering Measurement. *Conference IOP Conf. Series: Earth and Environmental Science, 654, 1-8*. doi:10.1088/1755-1315/654/1/012033.

Vale, I., & Barbosa, A. (2020). Gallery Walk: An active strategy to solve problems with multiple solutions. *Revista da Sociedade Brasileira de Educação Matemática, 17, 1-19. https://doi.org/10.37001/remat25269062v17id260*

Vale, I., & Barbosa, A. (2023). Active learning strategies for an effective mathematics teaching and learning. *European Journal of Science and Mathematics Education, 11(3), 573-588.* https://doi.org/10.30935/scimath/13135

Wang C, Geng F, Yao Y, Weng J, Hu Y, Chen F (2015) Abacus Training Affects Math and Task Switching Abilities and Modulates Their Relationships in Chinese Children. *PLoS ONE 10(10):* e0139930. https://doi.org/10.1371/journal.pone.0139930

Warfield, J., Wood, T. & Lehman, J. (2005). Autonomy, beliefs and the learning of elementary Mathematics teachers. Teaching and Teacher Education, 21(4), 439 – 456. https://doi.org/10.1016/j.tate.2005.01.011

Yakubu, L. & Bolaji, C. (2019). Impacts of Jigsaw Ii Co-Operative Learning Strategy on Academic Performance in Mensuration Among Secondary School Students in Kano State, Nigeria. *Abacus (Mathematics Education Series), 44(1), 19-27.* https://man-nigeria.org.ng/issues/ABA-EDU-2019-4.pdf

Zakariyya, A. (2022). Impact of Computer Aid Instructions on Locus of Control and Students' Performance in Mensuration of SSS One Students in Kagarko Local Government Area of Kaduna State, Nigeria. *International Journal of Scientific Research in Science, Engineering and Technology, 9(2), 19 – 30. https://doi.org/10.32628/IJSRSET229137*

Zhifeng, Y. (2017). The Characteristics and Methods of Autonomous Learning of Higher Mathematics. *Advances in Social Science, Education and Humanities Research, 96. 1259 – 1263.*

APPENDICES

Appendix A

Teacher Interview Questions – Final Draft

1. How do you feel about the new integrated curriculum?
2. What are the main expectations of the integrated curriculum, especially on the teaching strategies and learner's classroom behaviour and how do those compare with the old curricula expectations?
3. Have you received any training prior to arrival of this curriculum in your school?
4. What do you understand about active learning and teaching, and learner autonomy in a Mathematics classroom?
5. What role do you play in order to facilitate active learning in your Mathematics classroom?
6. With your definition of learner autonomy and active approach to teaching and learning, how would/do you teach Mensuration to help your students comprehend the topic thoroughly?
7. In a learner-autonomous Mathematics classroom,
   (a) How would/do you approach different learning styles?
   (b) How would/do you encourage your students to express their creativity, and maximise participation?
   (c) How would/do you modify your teaching to help students who are struggling with the subject or learning level?
8. What classroom practices do you think Mathematics teachers must master in order to promote learner autonomy and facilitate active learning in order to maximise learner conceptual understanding?

Reflection questions

1. How do you feel about the way you conducted the lessons?
2. To what extent do you think the learners were autonomous and actively involved in the learning processes?
3. What do you think was your role in this classroom during this lesson, and what was learners' role?
4. What improvements do you think you should do in your planning, teaching approach and classroom management in order to maximise learner active learning, promote learner autonomy and conceptual understanding?

Appendix B

Teacher Interview Questions – First Draft

1. How much are you aware of the introduction of the integrated curriculum in Lesotho schools? When was it introduced in schools, when did it reach the secondary level?
2. How do you feel about the curriculum?
3. What are the main expectations of the integrated curriculum, especially on the teaching strategies and learner's classroom behaviour? How do those compare with the old curricula expectations?
4. Have you received any training prior to arrival of this curriculum in your school?
5. Was it enough: how else would you like to be assisted in order to adequately implement the curriculum?
6. According to you (basic knowledge and experience) what are characteristics of a good Mathematics teacher?
7. What characteristics do students need/want their Mathematics teachers to possess?
8. Which effective methods of teaching do you use in teaching this new curriculum?
9. What do you understand about active learning and teaching in a Mathematics classroom?
10. What role do you play in order to facilitate active learning in your Mathematics classroom?
11. What role does learners' behaviour and discipline play in the teaching-learning process and what is your approach in this regard?
12. According to you, what is most important for the Mathematics learner, mastery and fluency of the computational procedures and formulae or conceptual understanding? Do you think they are both significant? Why? How do you approach your teaching such that you facilitate each of these?
13. What do you understand by learner autonomy in a Mathematics classroom? Do you think it is significant in Mathematics learning and teaching? What are your approaches in promoting it?
14. With your definition of learner autonomy and active approach to teaching and learning, how would/do you teach Mensuration to help your students comprehend the topic thoroughly? How do you determine if they have understood exactly what you taught?
15. In a learner-autonomous Mathematics classroom,

(d) How would/do you approach different learning styles?

(e) How would/do you encourage your students to express their creativity, and maximise participation?

(f) How would/do you modify your teaching to help students who are struggling with the subject or learning level?

16. What classroom practices do you think Mathematics teachers must master in orders to promote learner autonomy and facilitate active learning in order to maximise learner conceptual understanding?

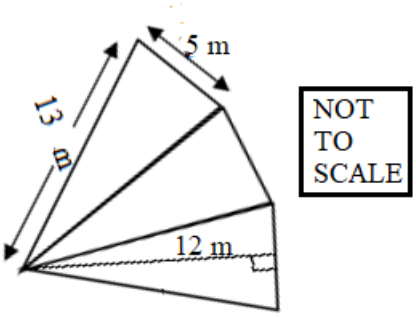
Reflection questions

1. What do you feel about the way you conducted the class?
2. To what extend do you think the learners were autonomous and actively involved in the learning processes?
3. What do you think should be your role in a classroom situation in which learners are actively engaged? Do you think these were executed in your class?
4. What improvements do you think should be done in your planning, teaching approach and classroom management in order to maximise learner active learning and promote learners' conceptual understanding?
5. What extra learning materials do you think your leaners need in order to maximise their active and independent engagement and conceptual understanding?

Appendix C

Learner Problem-set: Final draft

1. Mr Stue has a yard in his farm where he keeps his animals. The yard is a 12 sided regular polygon. The diagram shows part of the yard in which Mr Stue keeps his Sheep.



(d) Calculate total length of fence required to enclose the part in which Mr Stue keeps his Sheep.

(e) Calculate the area of the yard occupied by all the animals.

(f) Mr Stue wants to use the same length of the fence to reshape his yard such that it occupies a larger area.

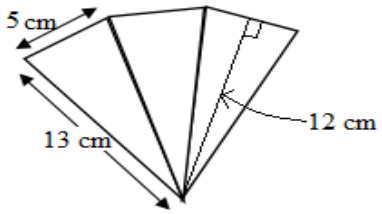
Describe the most suitable shape of the new yard Mr Stue can form. Support your description with appropriate reasoning.

Appendix D

Learner Problem-set: Task1: First draft

1. Mr Stue has a yard in his farm where he keeps his animals. The yard is a 12 sided regular polygon. The diagram shows part of the yard in which Mr Stue keeps his Sheep.

NOT TO SCALE



(a) Calculate

(i) total length of fence required to enclose the part in which Mr Stue keeps his Sheep. [2]

(ii) area of the yard occupied by all the animals. [3]

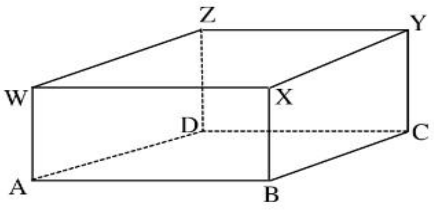
(b) Mr Stue wants to use the same length of the fence to reshape his yard such that it occupies a larger area.

(i) Describe the shape of the new yard Mr Stue can form. Support your description with appropriate reasoning.

(ii) Show that the new yard will be larger than the old yard.
Support your answer with appropriate workings and reasoning.

TASK 2]

1. A rectangular box with top WXYZ and base ABCD has AB = 6 cm, BC = 8 cm and WA = 3 cm



Calculate:

(i) length of AC

(ii) angle between WC and AC

2. A cylindrical solid of radius 7cm and height 25cm is cut equally from the top bottom resulting into equal half solids (see Figure 3). Find the total surface area of one-half solid. $\pi = \frac{22}{7}$ may be used.

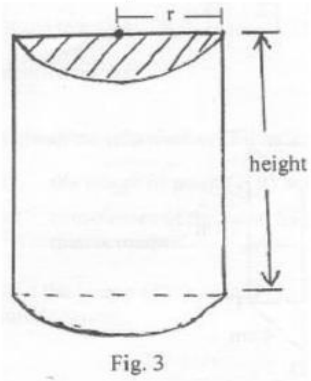


Fig. 3

Appendix E

Permission Letter to the Lesotho Ministry of Education and Training (MoET)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | WSoE Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 • Private Bag 3, Wits 2050, South Africa
Tel, +27 11 717-3411 • Website: www.wits.ac.za

The Principal Secretary Basic Education
Ministry of Education and Training
P.O. Box 36
Maseru 100
21 May 2021

Dear Sir/Madam,

Re: Permission to conduct research at Lesotho High Schools in Maseru district.

My name is Sikeme Raphoka.
I am studying for a PhD in Mathematics Education in the School of Education at the University of the Witwatersrand. I am seeking permission to do research at Maseru High Schools.

I am conducting research on the nature of classroom environments created by Mathematics teachers when teaching Mensuration on implementation of the new integrated curriculum which calls for Learner Autonomous Environments. The study focuses on how learners are engaged in their learning process with respect to the curricular proposed learner autonomous environments; how Mathematics teachers understand their role in promoting these environments and engaging learners for a better conceptual development; and how these environments influence learners' conceptual development in Mensuration. This research focus is triggered by an introduction of the new curriculum which comes with teaching-learning strategies which are radical in the Lesotho secondary school education system. In particular, the curriculum proposes an active approach to teaching and learning and learner autonomous classroom environments. As a result, the study demands to determine if the curriculum is well implemented and how teachers understand their role on implementation of these curricular expectations.
The study focuses on Mensuration since it has a bad performance history in Lesotho secondary education from the old curricula, and since it is mostly practical in nature and involves a number of formulae which could lead to teachers enforcing teaching-learning strategies such as memorization and drill-and-correct paper-pencil methods, in opposition to the new curricular expectations. Therefore, the study investigates if the new curricular objectives would instigate a

better conceptual development in Mensuration as understood and actuated by the teachers in their classrooms. The high schools in Maseru are selected as appropriate for this study due to their accessibility, availability of Mathematics teachers in adequate numbers per school and their varying performance rankings with respect to Junior Certificate examinations in the past years.

The research will entail collecting data from Mathematics teachers and their students during normal teaching sessions and out of class. If they agree, teachers will be asked to be interviewed and observed as they teach in their classes and students will be asked to take part in the focus-group discussions and writing of problem-solving tasks. The classroom observations and the focus group discussions (and problem-solving writings) will occur during the normal classroom teaching sessions during school hours. The teachers' interviews will be conducted at the convenience of each teacher (whether during school hours or not). As a result, each teacher will be required to spare up to 30 minutes of their time for interviews and a lesson length time for classroom observations which will be conducted three to four times per teacher (on different days). With the permission of each teacher and their students, all the data collection processes will be audio and video recorded.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the school) will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study. The results will be communicated anonymously in my thesis, academic journals and professional conferences.
The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

All research data will be anonymously preserved for reuse for some further research on permission of each participant involved. If anyone of the participants does not provide permission for reuse of such raw data, the data will be destroyed on completion of the project. I therefore request permission in writing to conduct my research at your school. The permission letter should be on your school's headed paper, signed and dated, and specifically referring to myself by name and the title of my study. Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Sikeme Raphoka
Contacts: +266 57331564; Email: 2422936@students.wits.ac.za;

Supervisor:
Dr Batseba Mofolo-Mbokane,
Email: batseba.mbokane@wits.ac.za; contacts: +27 (11) 717 3411

Appendix F

Permission Letter to the school principal

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | WSoE Wits School of Education

27 St Andrews Road, Parktown, Johannesburg, 2193 • Private Bag 3, Wits 2050, South Africa
Tel, +27 11 717-3411 • Website: www.wits.ac.za

The Principal
----------High School
P.O. Box-----
Maseru 100
21 May 2021

Dear Sir/Madam,

Re: Permission to conduct research at ---------- High School.

My name is Sikeme Raphoka.
I am studying for a PhD in Mathematics Education in the School of Education at the University of the Witwatersrand. I am seeking permission to do research at ----------High School.

I am conducting research on the nature of classroom environments created by Mathematics teachers when teaching Mensuration on implementation of the new integrated curriculum which calls for Learner Autonomous Learning Environments. The study focuses on how learners are engaged in their learning process with respect to the curricular proposed learner autonomous environments; how Mathematics teachers understand their role in promoting these environments and engaging learners for a better conceptual development; and how these environments influence learners' conceptual development in Mensuration. This research focus is triggered by an introduction of the new curriculum which comes with teaching-learning strategies which are radical in the Lesotho secondary school education system. In particular, the curriculum proposes an active approach to teaching and learning and learner autonomous classroom environments. As a result, the study demands to determine if the curriculum is well implemented and how teachers understand their role on implementation of these curricular expectations.
The study focuses on Mensuration since it has a bad performance history in Lesotho secondary education from the old curricula, and since it is mostly practical in nature and involves a number of formulae which could lead to teachers enforcing teaching-learning strategies such as memorization and drill-and-correct paper-pencil methods, in opposition to the new curricular expectations. Therefore, the study investigates if the new curricular objectives would instigate a better conceptual development in Mensuration as understood and actuated by the teachers in their classrooms. This school is selected as appropriate for this study due to its accessibility, availability

of Mathematics teachers in adequate numbers and its performance ranking with respect to Junior Certificate examinations in the past years.

The research will entail collecting data from Mathematics teachers and their students during normal teaching sessions and out of class. If they agree, teachers will be asked to be interviewed and observed as they teach in their classes and students will be asked to take part in the focus-group discussions and writing of problem-solving tasks. The classroom observations and the focus group discussions (and problem-solving writings) will occur during the normal classroom teaching sessions during school hours. The teachers' interviews will be conducted at the convenience of each teacher (whether during school hours or not). As a result, each teacher will be required to spare up to 30 minutes of their time for interviews and a lesson length time for classroom observations which will be conducted three to four times per teacher (on different days). With the permission of each teacher and their students, all the data collection processes will be audio and video recorded.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study. The results will be communicated in my thesis, academic journals and professional conferences.
The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

All research data will be anonymously preserved for reuse for some further research on permission of each participant involved. If anyone of the participants does not provide permission for reuse of such raw data, the data will be destroyed on completion of the project. I therefore request permission in writing to conduct my research at your school. The permission letter should be on your school's headed paper, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Sikeme Raphoka
Contacts: +266 57331564; Email: 2422936@students.wits.ac.za;

Supervisor:
Dr Batseba Mofolo-Mbokane,
Email: batseba.mbokane@wits.ac.za; contacts: +27 (11) 717 3411

Appendix G

Research Consent Form for Teachers

Title of Project: **Exploring the Nature of Grade 8 Classroom Environments Created by Mathematics Teachers when Teaching Mensuration: Curriculum Implementation in Lesotho**
Name of Researcher: RAPHOKA SIKEME

I, ……., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(**Please read carefully and circle the relevant options below)**

• I agree that my participation will remain anonymous	**YES / NO**
• I understand and agree that the research will involve: the classroom observations, and 20-30minutes interviews.	**YES / NO**
• I agree that the interviews may be audio recorded and that classroom observation may be video recorded	**YES / NO**
• I understand that all information about me will be treated in strict confidence and that I will not be named in any written work arising from this study.	**YES / NO**
• I understand and agree that any video and audiotape material of me will be used solely for this research purpose and will be destroyed on completion of the project.	**YES / NO**
• I agree that the researcher may use anonymous quotes in his / her research report	**YES / NO**
• I agree that the information I provide may be used in an anonymized format after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	**YES / NO**

I freely give my consent to participate in this research study and have been given a copy of this form for my own information.

Signature: ……; Name……..

Date: ……

Appendix H

RESEARCH CONSENT FORM (Learners)

Title of Project: **Exploring the Nature of Grade 8 Classroom Environments Created by Mathematics Teachers when Teaching Mensuration: Curriculum Implementation in Lesotho**
Name of Researcher: RAPHOKA SIKEME

I, …….., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(**Please read carefully and circle the relevant options below)**

• I agree that my participation will remain anonymous	**YES / NO**
• I understand and agree that the research will involve: the observed focus group discussions, and Mensuration problem-solving tasks.	**YES / NO**
• I agree that the group discussions and written work on problems-solving tasks may be audio and video recorded.	**YES / NO**
• I understand that all information about me will be treated in strict confidence and that I will not be named in any written work arising from this study.	**YES / NO**
• I understand and agree that any video and audiotape material of me will be used solely for this research purpose and will be destroyed on completion of the project.	**YES / NO**
• I agree that the researcher may use anonymous quotes in his / her research report	**YES / NO**
• I agree that the information I provide may be used in an anonymized format after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	**YES / NO**

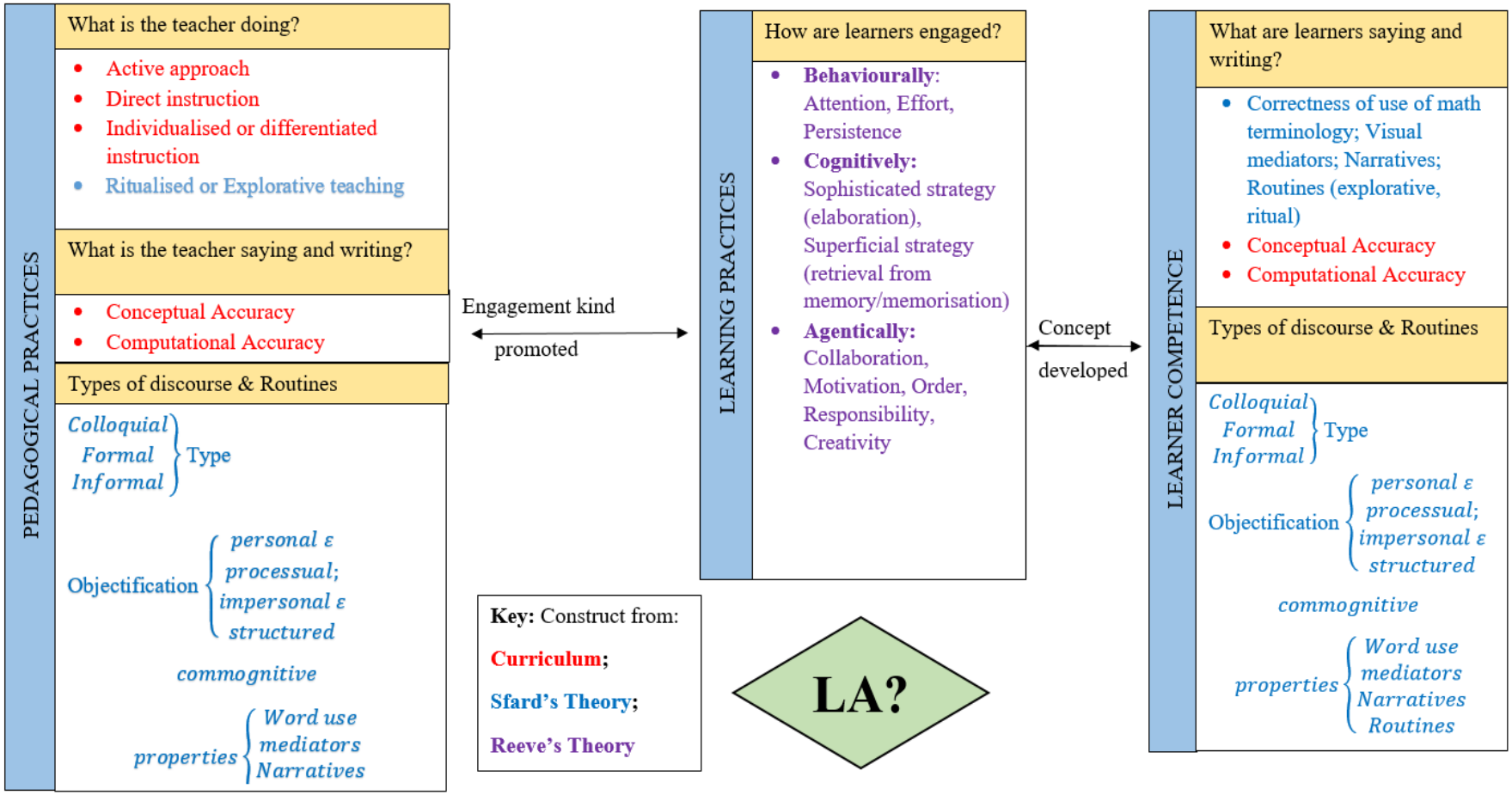
I freely give my consent to participate in this research study and have been given a copy of this form for my own information.

Signature: ……; Name……..

Date: ……

Appendix I

The Proposed Analytical Framework (old version)



Appendix J

The Data-codes with research questions (Codebook)

RQ(s)	Units of Observation, Codes		Descriptive Code Name & Acronym	Description & example
1: What types of instructional approaches (active vs direct) do teachers use in Grade 8 classrooms?	***Pedagogical Practices***	***Active Approach (AA)***	Responsibility/Narrative-seeking ; Prior knowledge seeking; application of learned procedures/concept (AA)	Teacher questioning to seek learner explanation/further explanation on procedure they used (confirmation that they grasped the procedure) and narrating a scenario or question to seek learners' thinking on new situation/concept. E.g. **T**: …So let's say we want to calculate the area of this triangle. We have this triangle and we want to calculate its area. How are we going to calculate the area of the triangle?
		Direct instruction (DI)	Introduce, emphasise, summarise-DI1	Teacher emphatically explains to introduce new concept/procedure or formula; summarises procedure/use of formula/ provides worked example explicitly out./reminding learners prior discussion/concept. E.g. **T:** So that says if you're asked to calculate the distance around any given shape or if you're asked to calculate the perimeter you have to add all the… measurements that are given from the shape. So you add all sides, that will give you the perimeter. And if your length is in centimetres that says, your length and the width if they are in centimetres that says the perimeter will take the units that we have from the shape, so your perimeter will be in centimetres. **Learners in Chorus:** Yes sir!
			Repeat-and-expand-DI2	Teacher repeats learner response/ procedure/re-explain learner-followed procedure to confirm it correct/project it/elaborate further. E.g. **T:**…What will be the distance around this rectangle? And how do you get it? [*selects a learner(Paul) who had raised his hand*] **Paul:** 22cm!... We add all sides together. **Teacher**: So we are going to add all four sides together. -we have 5cm plus 6cm, plus 5cm plus 6cm. Then adding these four u get 22.

			Instruct and hint-DI3	Teacher expertly explains the teacher-given problem, commands on what formula/procedure to use, concludes the lesson/discussion with thorough explanations providing new terminology/reminder on discussed concepts. E.g. **T**: .. let me see the workings…How did you multiply? **Momo**: … I said 3 times 2, it gave me 6 then I put 6 here. Then I said 3 times 5 then… **Teacher**: No…! Okay why do you start this side when multiplying? Start the other side, put zero and start with this one, multiplying from the right to the left…that's not how you do it…
			Confirmatory-lead-response- DI4	Teacher explanation/further explanations always followed by confirmatory questions; learners always provide **confirmatory responses**. E.g. **T**: And again you multiply the units. You have centimetres multiplied by centimetres so that will give you square centimetres. So the units of area will always be in square units depending on the units of your length and the width. If the length and the width are in metres, that says the final answer will be in square meters, right? **Learners** in a chorus: yes sir
		Ritualised[RR]; Explorative[RE] teaching	Routine as Ritual-RR1	Teacher questioning to edge learners to retrieve from memory (prior knowledge); explaining/further explaining (or probing) to make original question simpler/ after narrating a scenario to make it easily comprehended. E.g. **T:** So which are the 2-dimensional shapes that you know? [***T_4*** *moves from point to point expecting learners to answer, they remain silent.* **T**: The shapes that you know..Which are the shapes that you know? **Hlony**: Sir! (***T****: Mmh?*) A square.
			Routine as Ritual-RR2	Teacher commanding/encouraging learner to strictly use teacher-given formula/procedure. E.g. **T**: If you want to calculate the area of any triangle, then you should use this equation and for the area of a rectangle you use this one.
4: How do teachers and learners interact during the		***Pedagogical link-making: to support knowledge building***	Approach A- *PL1*	Involves making links between everyday/spontaneous ways of explaining and the scientific way of explaining.

teaching-learning of Mensuration concepts (Perimeter and Area)?			Approach A- *PL2*	Involves making connections between different and somehow related concepts as a way of learning the new scientific topic/sub-topic
			Approach A- *PL3*	Involves realistic connection between the classroom-taught scientific concept and the actual real-life phenomenon which exists in learners' everyday life experiences.
			Approach A- *PL4*	Involves making connections between different modalities of representing a concept and make sense on how these representations work together to make clear the concept and its sub-concepts
			Approach A- *PL5*	Involves making links between explanations at different levels: symbolic level - involving a variety of pictorial, algebraic and computational forms and representations; macroscopic level, which involve referring to students' spontaneous experiences; and (sub-)microscopic level, "comprising the particulate level, which can be used to describe the movement of electrons, molecules, particles or atoms") of explaining a scientific phenomenon.
			Approach A- *PL6*	Involves making links between the targeted scientific (which may seem too abstract to comprehend) and a well-known/familiar real-life phenomenon (an analogue) which could help learners to better understand the targeted concept
	Learning practices	***Pedagogical link-making for continuity & Link-making involvement***	Approach A- *PLa*	Link making to develop the scientific story (Macro, Meso, or micro level)
			Approach B - *PLb*	Link-making to manage/organise (macro, Meso, or micro level)
			Not-involved – LM0	Learners are not involved in link-making explanation
			Involved – LM1	Learners are involved in link-making explanation
		Communicative Approaches	Interactive/dialogic -I/D	Both teacher and learners talk interchangeably, learners raising opinions
			interactive/authoritative -I/A	Both teacher and learners' voices heard yet learners are not given chance to raise opinions argumentatively

			non-interactive/dialogic -N/D non-interactive/authoritative - N/A	Teacher provides explanations while at some point allows learners interruption with new ideas or questions Teacher provides explanations and does not allow learners to ask questions or provide interruptive opinions
(b) What types of discourses exist in these environments, when learning Mensuration? **&** **(c)** How do these types of classroom discourses influence how learners understand Mensuration concepts?	***Learner competences & classroom discourse/routines***	***Discourse objectification***	**Personalised and Processual – DO1**	Teacher/learner talk of mathematics objects/concepts as processes and resulting from their doings
			Impersonal and Structural – DO2	Teacher/learners talk of mathematics objects/concepts as structured and existing on their own
		Routines	**Rituals/Ritualised teaching – RR** **Exploration/Explorative teaching-RE**	Teacher/learner explanations/procedures lack substantiation (or prompt for) & done for uniformity/harmony/no production of endorsed narrative Teacher/learner explanations/procedures with substantiation/learner prompted to substantiate their responses/produce (or prompt for) endorsed narratives
		Conceptual/computational accuracy	**Conceptual accuracy/error – CA1** **Computational accuracy/error-CA2**	Teacher/learner commits (or not) conceptual error in talk/writing Teacher/learner commits (or not) computational error in talk/writing

Appendix K

Turnitin Report Summary

Sikeme_Thesis Submission 14 March 2024-1.pdf

ORIGINALITY REPORT

7%	6%	4%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.saarmste.org Internet Source	1%
2	wiredspace.wits.ac.za Internet Source	1%
3	www.tandfonline.com Internet Source	<1%
4	hdl.handle.net Internet Source	<1%
5	perpus.univpancasila.ac.id Internet Source	<1%

Appendix L

Nthabi's teaching approaches, Commognitive properties, Link-making & Communicative Approaches

Observable teaching Approaches	Pedagogical link-making and communicative approach
Eps1: ***Direct instruction:*** teacher repeating, correcting and further elaborating on learners' responses to make final narratives; giving examples and repeatedly reminding learners the definition and computational procedure in order for them to be able to work on the example and come up with correct responses; didactically working through the examples while leading learners with some leading and confirmatory questions throughout the computation process to get the correct answer; and telling learners how to determine the units of the final result. ***Active approach:*** probing learners to define Perimeter and suggest computational procedure for any given shape;	to support knowledge building - making links between modes of representation (definition and computational procedure of Perimeter); to support knowledge building - making link between scientific concepts (Concept of Length and Concept of Perimeter through their units of measure); dialogic/interactive communicative approach, non-interactive/authoritative communicative approach.
Eps 2: ***Direct instruction***: teacher didactically worked through the prove-check process while only leading learners with leading and confirmatory questions ***Active approach***: involving learners in working out the exercises from the textbook, on the classroom board; inviting confirmation from class on the answer done on the board	link-making to support knowledge building – making links between scientific concepts (properties of polygon and computational procedure for Perimeter). non-interactive/authoritative communicative approach.
Eps 3: ***Active approach:*** inviting a learner to work on the example on the board; inviting the class to prove-check the accuracy of the answer. ***Direct instruction:*** didactically explaining and working on the example to show how the multiplication operation become an alternative to the addition of sides operation; didactically leading learners in identifying sides of the parallelogram to use for computation of its Perimeter; Leading and confirmatory questions while explaining	link-making to support knowledge building - making links between modes of representation (the add-all-sides procedure and multiply-by-number-of-sides procedure for perimeter of regular polygon), interactive/authoritative communicative approach**,** and non-interactive/authoritative communicative approach.
Eps 4: ***Direct instruction***: provided learners with the formula (for Area of rectangle /square) and an example through which she worked to find the final answer; provided the formula for Area of triangle and a worked example; Leading and confirmatory questions as teacher explains; ***Active approach:*** probing learners to seek their thinking on new concept of Area; inviting learner to work out example on the board; commanding the rest of class to work on the example as well so as to prove-check the answer; allowing class to challenge the answer demonstrated on the board.	to support knowledge building: making links between modes of representation (linking definition of Perimeter and computational procedure/formula-algebraic representation) five incidences of interactive/authoritative communicative approaches and one incidence of interactive/dialogic communicative approach.
Eps 5:	no pedagogical links made

Direct instruction: repeating the procedure that learners explained and providing the equation which works best for a regular polygon (multiplication of number of sides by side length), and working on the example didactically to show the class how to obtain the correct answer; guiding-probe that included reminders for definition and computational operation for Perimeter. ***Active approach:*** Introducing a new shape with a learner probe on its properties; allowing learners to work on the example with new shape to see if they can calculate correctly; probing to seek learners' narration of their used procedure in obtaining the correct answer; probing to seek thinking and suggestion on any real-life objects for which they could calculate or measure Perimeter; using some engaging-scaffolding in which she persistently asked learners some questions, related to the diagram and the question in hand, to guide them to identify all the appropriate sides to use for Perimeter of the shape.	interactive/authoritative communicative approach

Commognitive properties				
Observed actions	**Word use**	**Visual mediator**	**Endorsed narrative**	**Routines**
Eps 1: Introducing Perimeter and its computational procedure: probing learners to define Perimeter and suggest computational procedure for any given shape; providing worked examples	Sides; distance; Perimeter; total; shape; Area; circle; square; centimetre; outside; around ; numbers; units	Drawn square of side 4 Drawn quadrilateral of sides 1, 1.5, 3, and 2 $1 + 2 + 3 + 1.5 = 7.5m$	'Perimeter is the distance outside the shape.' 'Perimeter is the distance around a shape' 'To calculate Perimeter, we are going to add all the numbers around the shape' 'If we are finding eh, the units are centimetres your answer has to be in centimetres' $1 + 2 + 3 + 1.5 = 7.5m$	Ritual to define Perimeter Ritual on how to find Perimeter by calculation (from definition to computational procedure)
Eps 2: Working on example calculating Perimeter; inviting learners to working out the example on the classroom board; didactically working through the prove-check process while leading learners with leading and confirmatory questions; inviting confirmation from class on the answer done on the board	Calculate; sides; shape; Perimeter; add; decimal; place-value; triangle;	Drawn triangle of dimensions 3.8, 3.5, 6; quadrilateral of dimensions 1, 4. 4.5 and 3; triangle dimensions 5.4, 2, 5 $3.8 + 3.5 + 6.0 = 13.3$ $4.3 + 3.0 + 4.0 + 1.0 = 12.5$ $5.4 + 5.0 + 2.0 = 12.4$	'We said that when we calculate the Perimeter of a shape we are going to add all the sides…' 'okay because 6 it's a whole number we have to write it in a decimal form and we are going to write it as 6.0,' $3.8 + 3.5 + 6.0 = 13.3$ $4.3 + 3.0 + 4.0 + 1.0 = 12.5$ $5.4 + 5.0 + 2.0 = 12.4$	Ritual to drill learners to memorise and perform the computational procedure accurately. Ritual: prove-check by class(and led by teacher) to ensure uniformity in the procedure and final answer
Eps 3: leading computations on for Perimeter of regular polygon/parallelogram; inviting a learner to calculate on the board; inviting the class to prove-check the accuracy of the answer;	Square; Perimeter; shape; equal; multiply; side; triangle; parallelogram;	square of side 2; equilateral triangle side 3cm; parallelogram sides 4, 2.4;$4 \times 2 = 8; 2 + 2 + 2 + 2 = 8;\ 2.4 + 2.4 + 4.0 + 4.0 = 12.8$	Square has all sides equal; 'So now in order to find the Perimeter if the sides are equal, you take the number of sides times the side'; $4 \times 2 = 8; 2 + 2 + 2 + 2 = 8;\ 2.4 + 2.4 + 4.0 + 4.0 = 12.8$	Ritual to introduce multiplication as alternative for repeated addition for calculation of Perimeter of equilateral polygon; Ritual to enable learners memorise rote procedures
Eps 4: Teaching Area of each type of shape as separate procedures; introduction	Area; space; inside; shape; enclosed; square;	Drawn square, rectangle, $Area = Length \times width;$ $A = L \times W$	'Area is space inside the boundary of a shape'; 'Area is equals to length by width' 'so when we find the Area of a	Ritual to show learners the formula for Area of rectangle and Area of triangle and how to use them to get correct answers

by probes on definitions and computational procedure; telling and writing the formulae for each shape; working on examples while leading learners through computation procedure; inviting learner for board demonstration of procedure;	squared; rectangle; length; Width; triangle; base; height;		triangle we are going to say this is half times base times height' $Area = Length \times width$ $A = L \times W$	
Eps 5: Teaching Perimeter of n-sided polygon with a learner-probe on its properties and example computations; giving problem-set and monitor progress; using some engaging-scaffolding related to the diagram and questions in hand; probe on rea-life application of Perimeter	Shape; sides; Perimeter; equation; distance Desk; classroom; dam; book; land; Fence; total length	Drawn octagon; $Perimeter$ $= number\ of sides$ $\times\ length\ of\ one\ side$ $= 8 \times 2cm$ $= 16cm$	'we said that this equation works only if all sides are equal' $perimeter$ $= number\ of\ sides$ $\times\ length\ of\ one\ side$ 'That is, you add the sides all of them to find that total length.'	Ritual to introduce new formula (for calculation of Perimeter) to learners and show them how it works. Ritual: interpreting scenario and directing learners how to answer questions

Appendix M

Nthabi's Learners' practices and Commognitive properties

Observed actions	Word use	Visual mediators	Endorsed narratives	Routines
Eps 6 Responding accordingly to teacher's leading probe questions on the computation process for Perimeter of an irregular shape; Narrating the computational procedure followed in finding their correct answer.	Sides; Numbers as responses (5,12,17,20,25);	Diagram of irregular pentagon	$8+4+5+3+5+8=25$	Learners' Ritual of rote responses on addition of sides to obtain their answer 25 - no reasoning provided. Teacher's Ritual to prove-check answer by recalculating while leading learners with questions – no questioning for substantiation of the procedure followed or answer obtained.
Eps 7 Learners' difficulty to relate problem scenario to concept of Perimeter taught; teacher direct guide to enable learners' interpretation; learners' ability to interpret scenario in home language.	Equal; three parts; fence; around; length; Perimeter; all sides; calculate; add; ***numbers as responses*** (5, 13);total; karolo; height; Area; potapota	Diagram of an irregular pentagon	'the fence is around the shape' 'to find Perimeter we calculate all the sides' 'that is, you add the sides, all of them to find that total length' 'So we are just going to add them, that is Perimeter of Mr. Stue's fence' 'mona ke side tse five' 're tlo batla Perimeter ea ho potapota mona'	Rituals: dependence on teacher's interpretation direction for way forward; Ritual: teacher's direct guide into interpreting and answering questions. Exploration: brainstorming in home language interpret question and decide on the operational procedure
Eps 8 Choosing the correct sides of the shape to represent height and base of the triangle; computational errors while using correct formula; Calculating total Area of the 12-sided regular polygon.	Base; height; kopanya; side; shape; equal; Area; triangle;	Diagram of an irregular pentagon; $A=\frac{1}{2}\times b\times H$	'base ke 5 height ke 12 ke ena,…re tlo multiply-a moona le moona e be rea li kopanya' $A=\frac{1}{2}\times b\times H$ $=\frac{1}{2}\times 60m^2$ $=30m^2$ $30\times 3=90m^2$ $A=30\times 12=360m^2$	Ritual: memorising formula without clear understanding of height and base of triangle Ritual: direct and elevated scaffold by teacher in showing how many sides should multiply –rote use of formula Exploration: brainstorming on what to do with 30 after calculating it

Appendix N

Permission letter from the Ministry of Education and Training

THE KINGDOM OF LESOTHO
MINISTRY OF EDUCATION AND TRAINING
MASERU DISTRICT EDUCATION OFFICE
P.O. BOX 47. MASERU 100.
22 322 755

11 August 2021

The Principal
[redacted] School
Maseru 100

Dear Sir/Madam

RE: RESEARCH

"The nature of classroom environment created by Mathematics teachers when teaching Mensuration on implementation of the new integrated curriculum which calls for Learners Autonomous learning Environments."

Mr. Sikeme Raphoka is a student who is conducting a research on the above stated topic. He therefore wishes to carry out a research at your School.

You are kindly requested to provide him with the information that he may require.

Thanking you in advance for your usual support.

Yours Faithfully

'MATSOLO MOHASI (MRS)
DISTRICT EDUCATION MANAGER (ai) - MASERU

MASERU DISTRICT EDUCATION OFFICE
2021 -08- 11
P.O. BOX 47 - MASERU 100 - LESOTHO
TEL: 2232 2755

Activate
Go to Set

Appendix O

Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Raphoka

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H21/07/41**
PROJECT TITLE	Exploring the nature of grade 8 classroom environments created by mathematics teachers when teaching mensuration: curriculum implementation in Lesotho
INVESTIGATOR(S)	Mr S Raphoka
SCHOOL/DEPARTMENT	Wits School of Education/
DATE CONSIDERED	23 July 2021
DECISION OF THE COMMITTEE	Approved Risk Level: Minimal
EXPIRY DATE	26 August 2024

DATE 27 August 2021 **CHAIRPERSON** J. Knight

(Professor J Knight)

cc: Supervisor : Dr B Mofolo-Mbokane

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

Signature

28/08/2021
Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES